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LITERATURE FOR 1914 ON THE BEHAVIOR OF THE LOWER INVERTEBRATES

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Allee (1) has tested the relation of rheotaxis in Asellus to metabolism, measuring the latter by means of the duration of life of the animal in solutions of KCN. As animals having a high degree of metabolism die more quickly in KCN a means is afforded of testing the metabolism of different lots. Those which showed the most strongly positive rheotaxis were those in which, other things equal, the degree of metabolism is the greatest. Certain modifying factors must be taken into consideration and for an account of these reference must be made to the original paper.

In another paper Allee (2) points out that the rheotactic response is especially adaptive in stream isopods and is more pronounced in *Asellus communis* from streams than in the same species from ponds. The distribution of stream isopods is largely accounted for by their rheotactic and thigmotactic reactions.

Allee and Tashiro (3) have studied the relations between rheotaxis in Asellus and the rate of production of CO_2, and find that in a given individual the reaction is positive when the CO_2 production is rapid and indifferent when the CO_2 production is low. Resistance to KCN is in inverse proportion to the production of CO_2. There are great differences in the reactions of different individuals and "the rheotactic reaction is an expression, not of the absolute metabolic rate of the animal, but of the relative metabolic rate to which the isopod is acclimated for the time being."

In a paper in general ecology of Folliculina Andrews (4) records a number of observations on the behavior of this form. Ordinarily the species lives in tubes secreted by its body, but it often leaves these and swims through the water; it is positively phototactic and thigmotactic, and these traits lead it to settle down upon the younger parts of plants to which it is usually found attached. There is a strong tendency for individuals to aggregate in groups.

Baunacke (5) has considered various organs which might possibly occasion the orientation of Limax and other mollusks to gravity. He excludes light, tactual, and chemical stimuli and finds that orientation occurs in a medium of the same specific gravity as that of the animals. The statocyst alone is considered to be the organ directly concerned in orientation to gravity. Mollusks from which this organ has been removed are unable to orient themselves to gravity in the normal way.

The orientation of crustaceans to gravity forms the subject of an extended discussion by Buddenbrock (7) who recognizes three distinct factors which conspire to preserve the normal position of these animals. There is (1) the tendency to present the dorsal surface to the light (Lichtrückenreflex) which the author finds to be widespread among pelagic crustaceans. Then there is (2) the orienting function of the statocysts, and (3) a general reflex dependent upon no particular organ which leads the animal to keep the ventral surface below. In some crustaceans orientation to gravity may persist after the destruction of both statocysts and eyes.

According to Cowles (8) the starfish *Ecinaster spinosus* moves toward a white wall and away from a black one.

Dice (9) has analyzed the factors involved in the vertical migrations of *Daphnia pulex*. At 20° C. Daphnias are normally positive to weak light but indifferent to light of higher intensity. Increase of temperature makes them less positive, while decrease of temperature makes them more so. Light of high intensity makes Daphnias positively geotactic, while a decrease of light intensity has the reverse effect. These responses help to explain the diurnal movements of these forms. During the day Daphnias, at least in certain localities, are found more in deeper water while they commonly rise to the surface at night. This migration is due in part to the direct influence of light, but

more to the effect of light upon geotaxis. Temperature also is a factor, as Daphnias tend to become positively geotactic in high temperatures and negatively geotactic in low. This has a marked influence in the seasonal migration of these animals. Other minor factors of migration are discussed, such as age and wave action. There is no diurnal rhythm independent of the direct action of orienting agencies.

Ewald (10) finds that Daphnia has two distinct modes of reaction to the light, the orienting response and a response to change in light intensity. By subjecting Daphnias to intermittent light Ewald found that the orienting response was not effected by the frequency of interruption, provided that the same amount of light was received in a given time. For the shock reaction, interrupted light affords a much more effective stimulus. Both types of response harmonize with the Bunsen-Roscoe law. Daphnias respond to different colors, and not only to light intensity.

Fasten (11), in an account of fertilization in a species of copepods, describes the copulatory activities of the male.

Galiano (12) has described, without indicating any general conclusions or discussing his results, a number of experiments on the chemotaxis of Paramecium. Reagents were used similar to those which Paramecium encounters under natural conditions, i.e., culture fluids, distilled water, and dilute alkaline solutions.

Herwerden (13) placed Daphnias in a horizontal glass vessel one end of which was closed by quartz. When ultra-violet light was passed through the quartz into the water the Daphnias became negative; when a piece of glass was interposed the reaction was discontinued. In specimens in which the eye was destroyed there was no negative reaction.

Hess (16) finds that the ambulacral feet of the starfish Astropecten retract under the influence of light. If only a small extent of the ventral surface of one ray is illuminated the feet struck by the light rays retract while the others are extended. The oral tentacles of Holothoria show a similar reaction. In both cases red light has little effect but blue and green readily evoke the response. Serpulas (14) react to change in light intensity like color-blind people, i.e., without regard to wave lengths of differently colored lights. Balanus reacts in similar way, ceasing its movements upon a diminution of the light.

H. Jordan (17) has studied in detail the function of the contractile fibers of the body wall of holothurians. Holothurians, actinians, annelid worms and many other forms are grouped in a division which Jordan calls hollow organ animals. In these forms the absence of internal or external skeleton is in a way compensated for by the presence of fluids within the animal which, when under pressure, afford a certain rigidity to the body. There is a detailed study of the general physiological properties of the muscles of holothurians as well as certain fibers of the skin which while different from other muscle fibers are shown to be contractile. These latter Jordan thinks have a special function of maintaining the tonus of the body, while all the more nearly typical muscles have their function limited to simple contractility. There is thus a separation of functions performed by striated muscles of higher forms similar to that which Von Uexküll describes for the two sets of fibers supplying the spines of the sea urchin.

Just (18) finds that at Woods Hole, Massachusetts, the swimming of *Platynereis megalops* occurs in July and August in the dark of the moon. The breeding activities may be studied in the laboratory although the males are rather delicate and as a rule live only a few days in receptacles of sea water. The male in swimming coils spirally about the body of the female and works forward until he gets into a position in which the female may seize his tail in her jaws. Just thinks that the sperms are swallowed by the female and fertilize the eggs internally, after which ovulation takes place by the rupture of the body wall. After copulation sperm may be found in the pharynx "whence they escape through lesions in the pharyngeal wall to the coelom."

Kafka (19) has given a valuable and welcome summary of work on the sensory reactions of the invertebrates.

Kanda (20) finds that the anterior end of *Paramecium caudatum* and *Spirorostum teres* is heavier than the posterior end and therefore the orientation to gravity shown by these forms cannot be a merely mechanical one. Differences in pressure of water on the two ends or sides of the body are so slight as to be negligible, and besides both these forms orient negatively to gravity in solutions of greater specific gravity than their body.

After excluding other theories, Kanda concludes that the statocyst theory of geotropism is the most tenable.

Kanda (21) has also studied the geotropism of Arenicola larvae, subjected them to various salts solutions isotonic with sea water and noted the influence of different media on the sense of the response. Calcium and magnesium ions tend to reverse the normally negative response, but their action tends to be neutralized by sodium. The metallic ions are considered to be the influential elements in reversing geotropism. The usual positive phototaxis of the larvae may be reversed by the addition of sodium chloride or potassium chloride, but the action of these salts may be antagonized by calcium chloride or magnesium chloride.

In a paper on the biology of the snail (Helix) Kühn (22) treats of hibernation, loss of weight in winter, and reactions to drought in summer. Helix can be made to come out of its closed shell when placed under moist conditions. It does not take dry food if its body does not contain a considerable amount of water.

The death feigning reflex of arthropods is described by Löhner (23), who not only reviews a considerable amount of literature on the subject but describes several experiments of his own on different species of diplopods. The destruction of the brain or decapitation makes the reaction much more difficult to elicit, but these operations do not destroy it entirely. If the nerve cord is cut the part anterior to the cut can be made to perform this reflex. The reflex is not shown by an isolated part of the body behind the fifth segment.

The reactions of Bursaria to food and the processes of digestion in this species have been carefully studied by Lund (24). Bursaria may reject certain kinds of solid materials while it takes in others, depending on the action of the ciliary mechanism of the oral cavity. Large particles either do not enter the oral sinus or are rejected before reaching the latter, while small particles may be carried into the deepest part of the sinus and then carried out in a stream which passes backward on the ventral side of the body. The amount and rate of food taking depends on the condition of the animal. Bursaria appears to have a faculty analagous to the sense of taste, as it rejects food

particles impregnated with various chemicals. There is a selective elimination of the contents of food vacuoles, as indigestible substances that have been taken in are soon gotten rid of.

Mast (25) has made an extended reply to a paper on Euglena by Bancroft, which was reviewed in this journal last year. The question at issue concerns the method of orientation, Mast upholding the previous contention of Jenning's and himself that it is brought about through a more or less modified form of the "motor reaction." It is impossible to give an adequate presentation of the arguments of Mast in a short space, and reference must be made to the original paper.

Metalnikov (26) finds that Paramecia that had injected Sudan powder so that they contained an average of 20 food vacuoles enclosing this substance, almost completely failed to take in Sudan on the following day, although they had been kept in the meantime in a fresh hay infusion. They took in other substances, such as carmin, sepia and egg albumen in abundance. If a mixture of nutritive and non-nutritive substances be given the Paramecium takes both at first, but later rejects the non-nutritive and continues to take nutritive material.

Orton (27) gives an account of the feeding mechanism and feeding reactions in brachiopods and certain polychaetes and discusses the evolution of similar food-taking mechanisms and their reactions in unrelated groups of animals.

Echinus miliaris were found by Orton (28) to aggregate into groups in the period of sexual maturity. Males and females were most frequently associated, but groups were not infrequently found containing but one sex.

In an extensive review of work on actinians Pax (29) has given a very useful resumé of investigations on the reactions and natural history of these animals.

The Smithsonian Institution has reprinted a paper by Pearse (30) on the habits of fiddler crabs, which was reviewed in an account of the literature for 1912 published in this journal last year.

Powers (31) has experimented on the reactions of four species of crayfish (Cambarus) to CO_2, HCl and acetic acid. In CO_2 the species die in the following order: virilis, propinquus, diogenes, immunis. All four species react more strongly to HCl than to acetic, and more strongly to acetic acid than to CO_2.

There seems to be a correlation between the specific reactions of the species and their habitats. In all the species the behavior is repeatedly modified owing, in the opinion of the author, to "increased sensitiveness on the part of the animals."

Pütter (32) has given a resumé of experimental work on the irritability of protozoans.

In the course of a detailed study of the structure of the infusorian Diplodinium, Sharp (33) records several observations on locomotor activity and the action of the membranellae.

Torrey and Hays (34) find that *Porcellio scaber* is negative in its reaction to light and may be driven about in any direction by light coming from behind. The first reaction of the animal when light is suddenly flashed upon it is to turn directly away. Orientation, the authors conclude, is direct although the method may be obscured by various random movements.

In the course of an account of the influence of various chemicals on *Colpidium colpoda*, Weyland (35) describes results of experiments on the chemotaxis of the species in relation to a considerable variety of compounds.

Zagorowsky (36) finds that Paramecia are positively thermotactic up to 32° C. but at 33° C. and above they become negative. The rate of swimming increases with rise of temperature up to 49° C. after which it rapidly falls and ceases at 55° C.

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LITERATURE FOR 1914 ON THE BEHAVIOR OF SPIDERS AND INSECTS OTHER THAN ANTS

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TROPISMS

1. *Chemotropism.*—By attaching shallow pans, containing kerosene, to the branches of trees, Severin and Severin (77) were able to catch large numbers of the Mediterranean fruit fly (*Ceratitis capitata*). Out of 5,490 flies trapped in eighteen days only thirty were females. As these authors say, "It is certainly peculiar that the Mediterranean fruit fly plunges into kerosene to its own destruction." By using pans of four different colors (white, black, blue and orange) they demonstrated that the number of flies secured was not determined by the color of the pan. They think it highly probable that the sense of smell plays an important rôle in attracting the flies, and admit that it might be a positive chemotaxis due to one or more hydrocarbons or to the impurities of the petroleum oils. "Again, the hydrocarbons of the oil may act as an anesthetic, and stupify the insects whenever they remain within its influence." Neither of these suppositions, however, accounts for the preponderance of males. For a period of eight months these flies were trapped daily. During that time only three victims out of every thousand were females. Admitting that the proof is not conclusive, these investigators believe that the kerosene emits a scent similar to "some sexual odor of the female which in natural conditions serves to guide the male to her." This harmonizes with Howlett's interpretation* of the reaction of *Dacus zonatus* to the oil of citronella.

In another paper (78) these two investigators have discussed the relative attractiveness of vegetable and petroleum oils for the Mediterranean fruit fly.

2. *Hydrotropism.*—In two different species of water beetles,

* Howlett, F. H. The Effects of Oil of Citronella on Two Species of Dacus. *Trans. Ent. Soc.*, London, 1912, pt. II, pp. 412-418.

that inhabit a pond of about 300 square feet, Weiss (98) observed interesting cases of what he calls positive hydrotropism. When the wingless beetles *Gerris marginatus* were removed one to nine yards from the pond they immediately returned to it. When removed ten yards from the water they had some trouble in getting started in the right direction; but finally reached the pond. Thirty yards from the water they seemed to be lost. The case of *Dineutes assimilis*, a winged beetle, is even more interesting. When removed nine or ten feet from the water, it tried to walk to the pond, then arose and flew directly to it. When removed to a distance of seventy-five feet, it walked about in all directions, then arose, on its wings, to a height of twenty feet and flew directly to the water. When removed half a mile from the pond, it soared in a widening sub-spiral to a height of seventy-five feet and flew off in the direction of the water. He does not know whether they reached the water or not.

3. *Phototropism.*—Beutel-Reepen (6) does not think swarming honey bees are positively heliotropic.

OLIGOTROPISM

Robertson (75) does not accept the opinion that "Therefore the entomophilous flora of a region, as a whole, is not better pollinated because a part of the bees are oligotropic than it would be if they were all polytropic." He writes: "My view is that the bee fauna is all that the flora will support, that there is a constant competition between bees, and that natural selection favors those which are the most diversified, i.e., the least competitive in food habits." He believes that short flight is a result of oligotropy. To show the reasonableness of his contention he insists that if a bee limits itself to a given species of flowers it gains the immediate advantage of being able to anticipate others in their visits to the chosen plant. By locating near the flowers, it may augment this advantage, and, by concentrating its attention on that flower, learn to manipulate its pollen to greater advantage and even develop special structures which will increase this advantage. In support of this last statement, he cites the following examples:—(1) Bees that collect large pollen have loosely plumose scopae, while others which collect from the compositae have densely plumose scopae. (2)

Oenothera, the evening primrose, has its pollen grains connected by threads. *Anthedon compta*, an oligotrope of this plant, unlike its nearest relatives, has scopae of long single bristles. The bee goes to the stem and turns head downward, so as to work the cob-webby pollen into the scopae. (3) The anthers of *Verbena* are included in a slender tube and above them is a circle of hairs which impresses one with the thought that they were intended to prevent the extraction of the pollen. *Verbenapsis verbenae*, the oligotrope of this flower, has her front tarsi provided with curled bristles. The bee thrusts both front feet into the corolla and drags out the pollen with her front tarsi.

According to Robertson, there are 223 indigenous nest-making bees. One species flying the entire season, and fitted about as *Apis*, might collect nearly as much pollen and support nearly as many individuals. It would be to its advantage to be as polytropic as possible. " The ecological specialization exhibited by *Anthedon*, *verbenapsis* and other oligotropes is a fairly certain indication of the pressure of competition." The long-tongued pygidial bees were developed as competitors of the bumble bees, the first on the ground and the most polytropic of all bees. This explains their short and rapid flight and their oligotropic habits. Likewise the *Andrenidae*, the *Panurgidae* and related groups, which are often oligotropic, were probably preceded by the *Halictidae*, the most polytropic of all short-tongued bees. There are forty species of *Halictidae* flying throughout the season. There are ninety-four other short-tongued bees occupying the same region. It would be a hard matter for all to fly throughout the season and compete with the *Halictidae*. They have short times of flight, so distributed that not more than fifty-two are flying in any month and these only in the spring, when the *Halictidae* are the least abundant. All these bees are least abundant when the *Halictidae* are most abundant. " The early maximum flight, the non-competitive phenological distribution, and the frequent oligotropic habits indicate that these bees have managed to hold their own only by dividing up the remaining field and occupying the most favorable corners left by their polytropic competitors."

Lovell's views upon the origin of oligotropism are diametrically opposed to those of Robertson. In his recent reply (52) he makes the following criticisms:—

1. There is no evidence to support Robertson's contention that *Epiolus* is a parasitic genus.

2. To Robertson's assertion that a strenuous struggle for food is the determining factor in the evolution of the habits of bees, he replies that the size of the bee fauna is limited by other factors than the food supply. He insists that the commonness of an insect species does not depend alone on the quantity of available food, and gives the following specific proofs that only part of the available food is gathered by bees:—(a) In Riverside County, California, the orange bloom secretes nectar so freely that it drops upon the teams and clothing of the pruners in such copious amounts that, at the close of the day, it is necessary to wash the horses and the harness. (b) Hundreds of acres of the sandy coastal plain of Georgia are covered with bushes of the common gallberry (*Ibex glabra*). It is in bloom for a month and secretes nectar constantly. According to J. J. Wilder these flowers are seldom visited by bees.

3 To Robertson's hypothesis that, in the remote past, oligotropism arose through the competition of the long-tongued pygidial bees with the *Bombidae*, and of the *Andrenidae* with the *Halictidae*, Lovell replies: "This highly imaginative supposition cannot be supported by historical data, and would appear to be neither probable nor necessary." The polytropism of *Halictus* is due to its peculiar economy. The impregnated females hibernate and appear the following spring. The new generation flies during the latter part of the season. "This economy has no special advantage, for *Halictus* is greatly surpassed by *Andrena* in both species and individuals; while *Sphecodes*, which has essentially the same economy as *Halictus*, is represented by comparatively few species and individuals.

It is an advantage for a social bee to maintain its organization throughout the season; but for a solitary insect it is desirable that it mate and deposit its eggs as soon as possible. The longer the female flies before this happens the greater the probability that she will be destroyed by some one of many causes. * * * Since many polytropic bees have either a short term of flight, or one which does not exceed a hundred days, it is clear that a shorter term of flight is not necessarily correlated with oligotropism."

4. If severe competition did exist among solitary bees the

oligotropic habit would not be desirable. It is not an advantage for a bee to confine its food to one kind of plant unless it is always certain to obtain the supply it needs. By overstocking a locality oligotropic bees would disappear or become polytropic.

5. The genus *Perdita* contains about 150 species, practically all of which are oligotropic. An examination of the habits and characteristics of the genus should throw some light upon the origin of oligotropism. The facts are these: (a) the species are mostly small; (b) they do not take long flights; (c) a part of the species are vernal, but the majority fly in late summer and autumn; (d) many visit the *Compositae*; (e) oligotropism is as pronounced where there is only one or a few species as where there are many; (f) many flowers are visited by more than one species of *Perdita*; (g) the length of the tongues of bees limit them to certain flowers, " thus it is the tube-length of the flower, not competition, which is the factor limiting the visits of many species of Perdita; (h) female inquiline bees do not gather pollen and nectar for brood-raising and require only nectar for themselves; nevertheless, many such bees, with short terms of flight, visit only the *Compositae*.

Lovell concludes: "According to the theory proposed by the writer certain bees have become oligotropic because of the direct advantage gained, combined with the fact that their flight was synchronous, or nearly so, with the period of inflorescence of the plant to which they restricted their visits. This theory offers an explanation of the rise of oligotropism by the observation of existing conditions. There may be, and often are, accessory factors, but they are of secondary importance. * * * Robertson concedes all that is required when he says, ' The average flight is shorter and there are more of them with a short flight.' "

AUDITORY SENSATIONS

Hitherto the contributions to the experimental study of the sense of hearing of butterflies and moths have been fragmentary. As far as the moths are concerned, Turner and Schwarz (89) and Turner (86) have attempted to remedy this defect. In their joint paper (89) these investigators report the results of laboratory experiments with *Catocala unijuga* and field experiments with *C. flebelis*, *C. habilis*, *C. neogama*, *C. piatrix*, *C.*

retecta, var. *luctuosa*, *C. robinsona*, *C. vidua*, *C. amica*, *C. epione*, *C. neogama*, *C. ilia*, and *C. innubens*. The human voice, the Galton whistle and organ pipes were used to produce sounds. Except for special reasons, these instruments were always sounded where they could not be seen by the insect. To test the ability of the moths to respond to sounds to which they were usually passive, the following method was employed. Simultaneously with the sounding of the note the moth was gently touched. This was repeated one or more times and then the pitch was sounded without the tactile sensation. These authors reached the following conclusions:—" 1. Our field experiments demonstrate that several different species of *Catocala* moths respond to certain high pitched notes of the Galton whistle; but that they do not usually respond to notes of low pitch, such as the rumbling of trains, etc. 2. Most specimens responded to a high note by flying to a nearby tree; but some, and this was especially true of *C. retecta*, responded by making quivering movements with its wings. 3. The degree of responsiveness was not the same for all species. Among the least responsive were *C. vidua*, *C. neogama;* and at the other extreme were *C. flebelis*, *C. habilis* and *C. Robinsoni*. 4. We do not consider the failure of these moths to respond to certain sounds of a low pitch a proof that they do not hear such sounds; indeed, we are inclined to believe that these creatures respond only to such sounds as have a life significance. Three things render this last supposition probable: (1) the fact that *unijuga*, which at first did not respond to whistling, did so readily after once a blast of air had been allowed to strike her body simultaneously with the sounding of the whistle; (2) that most of the natural enemies of these moths produce high pitched sounds and trains and brass bands and other producers of low pitched sounds do not directly affect the survival of these moths; and (3) by carefully conducted field experiments we were able to induce three specimens of *C. neogama* to respond to sounds to which the species does not usually react."

Turner (86) reports the results of laboratory experiments with 79 specimens of *Samia cecropia* Linn., 104 of *Philosamia cynthia* Drury, 41 of *Callosamia promethea* Drury, and 81 of *Telea polyphemus* Cramer. These experiments were conducted in a building so constructed that it was impossible for the vibrations of

the sounding body to reach the specimens by any medium other than the air. For producing the tones, the following instruments were used: an adjustable organ pipe, an adjustable pitch-pipe, and an Edelmann's Galton whistle. The moths were confined beneath wire dish covers. Preliminary experiments demonstrated that each of the instruments could be held a short distance from the moths without causing a response, hence it was unnecessary to hide the instruments; precautions were taken, however, to prevent drafts caused by the instruments from impinging on the moths. To all ordinary tones *Telea polyphemus* is non-responsive. To see if this was due to deafness or merely to a refusal to respond to the stimulus, the following method was employed. "The organ-pipe was sounded five times in rapid succession. Immediately thereafter the insect was roughly handled for a few minutes. It was tossed about, gently squeezed and thrown upon its back. This was repeated over and over again, sometimes in one order and sometimes in another. After the moth had quieted down the whistle was sounded again five times in rapid succession. At each sound of the pipe the moth would wave its wings. The author has tabulated the effects of age, temperature and sex upon the responses. The paper concludes as follows:—" 1. It seems certain that all four species of the giant silk-worm moths investigated can hear. Three of the species respond to a large range of sounds. The third, *Telea polyphemus*, normally does not respond to sounds, unless remaining as immobile as possible be considered a response. By experimentally causing the moth to associate some disagreeable experience with certain sounds, it can be induced to respond to these sounds. 2. There is much evidence that the response of moths to stimuli is an expression of emotion. The fact that an insect does not respond to a sound is no sign that it does not hear it. The response depends upon whether or no the sound has a life significance."

OLFACTORY SENSATIONS

See Severin and Severin under chemotropism.

Beutel-Reepen (6) discusses the olfactory sense of the honey bee and thinks Forel's flasks are olfactory organs.

In a series of papers McIndoo (56, 57, 58) has made a substantial contribution to our knowledge of the olfactory sense

and of the olfactory organs of insects. He experimented with honey bees, hornets, ants and spiders. The following odors were used: oil of peppermint, oil of thyme, oil of wintergreen, bee food, pollen from old combs, parts of plants, flowers of the honeysuckle, leaves and stems of pennyroyal, spearmint, scarlet sage and bee stings. The odoriferous substances were isolated in stoppered vials. These vials were opened near, and usually below, the insects. Under normal conditions all of these creatures responded to the odors; usually by moving away from them. Evidently all of these forms can smell.

McIndoo thinks he has settled the debated question as to the location of the olfactory organs of insects. The belief that the antennae are the olfactory organs of insects is so widely spread that few except specialists know that the location of these organs is a debatable question. The following epitome of McIndoo's extensive bibliography will give an idea of the diversity of opinion on this subject. The seat of the olfactory organ is supposed to be in the spiracles by Sulzer (1761), Dumeril (1797), DuBois (1890), Hermbstadt (1811), Baster (1798), Lehmann (1799), Cuvier (1805), Straus-Durckheim (1828), Lacordaire (1838), Brulle (1840); located near the spiracles by Joseph (1877); in the glands of the head and body by Ramdohr (1811); in the oesophagus by Treviranus (1816); in the folded skin of the forehead by Rosenthal (1811); in the rhinarium by Kirby and Spence (1826); near the eye by Paasch (1873); in the mouth cavity by Huber (1814); in the epipharynx by Wolff (1875); in the palpi by Lyonnet (1745), Bonnsdorf (1792), Knoch (1798), Marcel de Serres (1811), Newport (1838), Driesch (1839), Perris (1850), Cornalia (1856), Weismann (1889); in antennae (belief based on structure) by Reaumur (1734), Lesser (1745), Sulzer (1776), Fabricius (1778), Bonnet (1781), Olivier (1789), Latreille (1804), Samonelle (1819), De Blainville (1822), Robineau Desvoidy (1828), Carus (1838), Percheron (1841), Goureau (1841), Pierret (1841), Robineau-Desvois (1842), Slater (1848), Dufour (1850), Claparede (1858), Donhoff (1816) Noll (1869), Wonfor (1879), Henneguy (1904); in antennae (belief founded on experiments) by Duges (1838), Lefebvre (1838), Küster (1844), Perris (1850), Cornalia (1856), Gardnier (1860) Balbini (1866), Forel (1874, 1885, 1908), Trouvelot (1877), Layard (1878), Slater (1878), Chatin (1880), Lubbock (1882), Plateau (1886),

Graber (1887), Dubois (1895), Fielde (1901, 1903, 1905), Piéron (1906), Wheeler (1910), Barrows (1907), Kellogg (1907), Sherman (1909); in various structures on the antennae by Erichson (1847), Burmeister (1848), Vogt (1851), Wonfor (1874), Bergmann and Leucjhart (1852), Leydig (1860, 1886), Lowne (1870), Claus (1872), Mayer (1878, 1879), Reichenbach (1879), Hauser (1888), Kraepelin (1883), Schiemenz (1883), Sazepin (1884), vom Rath (1887, 1888), Ruland (1888), Nagel (1892, 1894, 1909), Dahlgren and Kepner (1908), Börner (1902), Schenk (1903), Rohler (1905), Cottreau (1905); Berlese (1906) in the caudal stylets by Paxkard (1870); on the base of the wings and on the legs by Hicks (1857, 1859, 1860), Bolled, Lee (1885), Hauser, Janet (1904, 1907).

To settle experimentally the question McIndoo amputated the antennae of certain bees, wasps and ants and covered the antennae of others with shellac or celloidin. Such mutilated bees were abnormal in their behavior; sometimes they would respond to odors and sometimes they would not. Bees with maxillae and labial palps removed responded to odors the same as normal bees. Bees with the proboscis removed, bees with the mandibles amputated and bees with the buccal cavity plugged with paste responded to odors. When the bases of the wings were glued and when the legs were covered with vaseline and beeswax the insects were much slower than usual in responding to scents. These experiments caused McIndoo to agree with Hicks that certain peculiar pores found on the base of each wing and on the legs are the olfactory organs. In his latest paper, McIndoo (56) makes the following criticisms of the researches of most of his predecessors:—(1) Most investigators study the behavior in captivity for only a short time and others did not investigate the behavior of the unmutilated individuals. (2) When the antennae are injured or removed the insect is no longer normal. (3) In the honey bee the pore plates can scarcely be considered olfactory, for the male has eight times as many as the female, but responds to odors less frequently. (4) The pegs may be eliminated because they do not occur in the drones. (5) Pore-plates are not the olfactory apparatus of insects, for they are entirely absent in the *Lepidoptera*. (6) Spiders smell; yet they have neither antennae nor any organ that corresponds to them. He closes with the following sentence: " In conclusion, it seems

that the organs called olfactory pores by the author are the true olfactory apparatus in the *Hymenoptera* and possibly in all insects and that the antennae play no part in receiving the stimuli."

VISUAL SENSATIONS

See Severin and Severin under chemotropism.

Beutel-Reepen (6) thinks colors and odors attract bees to flowers.

Lovell (53) cites several examples of black animals and of people clothed in black being attacked by bees; while white animals, in the same situations, were unharmed, thus supporting the apiarists' belief that a beekeeper receives more stings when clothed in black than when dressed in white. In one experiment he wore a black veil and a white suit, with a black band on one of the sleeves. When the bees were disturbed they attacked the black veil and the black band, but not the white clothing. He repeated the experiment using a white veil and a black suit, with a white band on one sleeve. This time the bees attacked the black suit, but neither the veil nor the white band.

In another contribution (51), he makes the following objections to Plateau's statement that the odor of nectar is necessary to attract bees to flowers:—(1) "The cornflower and several gentians have odorless, conspicuous, nectiferous blossoms, which are visited by numerous insects. (2) The nectarless and odorless wind-pollinated flowers of the elm are visited by countless numbers of pollen-seeking honey bees. (3) The highly scented and conspicuous flowers of the sweet-pea and of certain varieties of *Pelargonium* are not visited by insects. Plateau claims that the odorless, but conspicuous, blossoms of the following plants are not visited by bees: *Clematis Jackmanni*, *Pelargonium zonale*, Willd., *Lilium candidum* L., *Pisum sativum*, *Passiflora adenophylla* Mostera, *Oenothera speciosa* Nuttall, *Linum candidum*. Discovering that the placing of the oil of anisette on these flowers would cause insects to visit them induced Plateau to conclude that it was the odor that attracted them. Lovell found that the placing of odorless sugar water on these flowers causes them to be visited by insects. According to Lovell, a certain man had two apiaries situated two miles apart. In the fields of one frequent rains had produced an abundance of clover

with long corollas; in the fields of the other a drought had caused the clover to have short corollas. In the second clover-field the bees were so abundant that they stung the men who attempted to mow the clover. In the first field there were practically no bees. Evidently, the presence of the bees in the former field was caused by neither the color nor by the odor, but by the accessibility of the nectar. Lovell's paper closes with the following conclusions:—" Entomophilous flowers are usually characterized by the possession of either bright coloration, or odor, or both, although apparently to some extent the two qualities are mutually exclusive. Both allurements are useful in attracting the attention of insects; but the absence of either conspicuousness, or odor, or both, will not necessarily cause a flower to be neglected if it contains an ample supply of nectar or pollen. But under similar conditions, small, green, odorless flowers, even if rich in nectar, will not be discovered as quickly as nectiferous flowers, which are conspicuous or agreeably scented. On the other hand, the possession of both color and odor will not ensure frequent visits in the absence of available food materials. The experiments afford no evidence that bees visit flowers for the purpose of experiencing an aesthetic pleasure. Insects, especially bees, occasionally examine the neglected conspicuous flowers of cultivation; but, obtaining no food materials, or very little, they do not often repeat their visits. Many neglected flowers are pleasantly scented and the addition of another agreeable odor is neither necessary nor beneficial. When odoriferous fruit syrups are introduced into conspicuous flowers, commonly neglected, a group of miscellaneous insects, especially Diptera, will be attracted; but the inference that, therefore, color is no advantage and an agreeable odor is required is fallacious. For the introduction of an odorless syrup into similar flowers will induce insect visits in large numbers; also when flowers, with the nectar inaccessible to honey bees and, consequently, seldom visited by them, have the nectaries artificially punctured, or the floral tubes shortened by drought, they are then visited by bees in countless thousands without the addition of either an agreeable odor or a sweet liquid. Flowers which in one locality freely secrete nectar and are visited by numerous insects are sometimes in other localities nectarless and almost entirely neglected. Insects, therefore, perceive the colors and forms of neglected flowers,

and the rarity of their visit is the result of their memory of the absence of food materials, not because the flowers lack an agreeable odor, which is often not the fact. The flowers into which Plateau introduced odoriferous sweet liquids were thus artificially converted into distinct physiological varieties. Since flowers possessing conspicuousness, an agreeable odor, and a liquid food are opposed to flowers possessing only conspicuousness, it is clear that color was never brought into competition with odor—the latter was invariably given the advantage. Colors and odors attract the attention of insects, but bees in their visits to flowers previously examined by them, are guided largely by the memory of past experience; they are able to associate different sense impressions and unconsciously make analogous inferences."

MATING INSTINCTS

McDermott (55) gives a resumé of the literature showing that in the Annelid worms and in the Lampyrid beetles phosphorescence is a mating behavior. He relates that the habits of the phosphorescent Elaterid genera *Pyrophorus* and *Photoporus* are unknown; and that *Bolitophila luminosa* is the only known self-luminous fly.

According to King (47), the littoral mite, *Gamasus immanis* Berl., mates the latter part of August, in a manner similar to that recorded for *G. terribilis* by Michael in 1886.

Triggerson (85) observed that the male of *Dryophanta ericacea* begins courtship by striking the female several times with his antennae. These taps quiet the female and render her submissive.

NEST BUILDING AND MATERNAL INSTINCTS

Detailed descriptions of the nesting and maternal habits of the mason bees of his part of France are given by Fabre (23).*

* The small space given to the discussion of Fabre's work is due not to a lack of appreciation for him on the part of the reviewer; but to the fact that these articles were originally published, in the French, several years ago, and it is believed that most students of animal behavior are familiar with them in the original. The reading of all of Fabre's works will well repay any student of animal behavior. One will not always agree with his interpretation of the facts; for, to the day of his death, he was uncompromisingly opposed to the theory of evolution. He stands toward the animal behavior men of today in the same relation as did the elder Agassiz to the morphologists of his day. Agassiz had collected a wealth of material which he interpreted in terms of types of created things; but which his followers, assisted by additional researches, interpreted in terms of morphological evolution. Likewise Fabre has collected a wealth of material which he interprets in terms of preestablished and unchangeable instincts; but which his followers, assisted by additional researches, will interpret in terms of mental evolution.

Branch (10) states that *Entyla sinuata*, one of the Membracidae, oviposits in a slit which the female makes in the midrib of the underside of the leaf of the thistle *Cnicus altissimus*.

Weiss (99) informs us that the nest of *Paratenodera sinensis* consists of a horny core containing eggs, surrounded by a rind, which undoubtedly protects the egg from moisture and from sudden changes of temperature. By a long series of tests, he proved that the eggs were not subject to sudden changes of temperature.

Williams (102) has given us the following interesting facts about the behavior of certain Hymenoptera. The nest of *Mimesa argentifrons* is a vertical funnel surmounted by a frail cone of agglutinated grains of sand. *Priononyx thomae* Fab. deposits her prey in a place of safety while she constructs her one-celled burrow. *Priononyx atrata* St. Farg. digs its burrow with jaws and forefeet. When the time comes to close the burrow, the wasp fills it by backing in and throwing in dirt at the same time. After using her clypeus and jaws as a packer or ram the wasp smoothes over the burrow with strokes of her feet and then covers it with bits of soil, sticks, etc.

In another paper (101), he informs us that the Larridae of Kansas are partial to sandy situations and that they almost invariably excavate their own nests. Occasionally they build in brambles; but the majority of the species mine in the ground. With the exception of *Miscophus*, the egg is placed transversely.

Strand (83) discusses the nest of an American Eumenid wasp and its inhabitants.

Dwight Isely (43) describes the nesting habits of six mining and two mason wasps of the family Eumenidae. The mining wasps belonged to the genus *Odynerus*. Each moistens the clay in which it is going to excavate with water brought, in periodic trips, from a nearby pond or stream; but, there is a marked contrast between their nests. The striking thing about many of these nests is the turret built around the entrance, out of a portion of the materials removed from the burrow. *Odynarus papagorum* Viereck constructs a turret which is durable under all ordinary conditions. The turret of *Odynerus arvensis* Sauss. is so frail that even a light rain destroys it. When the burrow of this species has been stocked, the wasp demolishes the turret and throws it, piece by piece, into the burrow. *Odynarus dor-*

salis Fab. does not construct a turret. *Odynarus annulatus* is variable in its habits. Sometimes it constructs a burrow with a turret and sometimes it uses an abandoned nest of *Pelopeus*. All of these burrowing species make locality studies before beginning their excavations. Many of these forms suspend the egg from the ceiling by a thread. Fabre thought this a device to prevent the egg from coming in contact with the squirming larvae. As Isely says, this cannot be true in all cases, for often the caterpillars are packed closely about the egg.

Beutel-Reepen (7) is convinced that the bees have ascended from forms having the habits of the digger wasps, and he crystallizes his opinion in the following table:

BIOLOGICAL ANCESTRAL TREE OF BEES

Meliponidae	Apidae	
(Stingless bees) *Melipone* and *Trigonae* about 170 species	Bombidae (Bumble bees) about 250 species	Apinae (Honey bees) (*Apis mellifica*) (*A. indica*) (*A. florea* (*A. dorsata*)

Females (old) and unfertilized young females bearing parthenogenetic eggs working together in the old nest. Beginning of the one-family colony.
(?)

Females see the brood emerge. Guard the nest. Honey-comb-like arrangement of cells.
(*Halictus quadricinctus*)

Females see brood emerge. Guard the nest.
(*Halictus sexcinctus*)

Females die before the brood emerges.

- Females, two and more, occupy a burrow in common, but each cares only for its own young. (*Panurgus, Halictus, Osmia, Eucera*, etc.)
- Females, or females and males over-winter together. (*Halictus, Ceratina, Xylocopa*, etc.)
- Females, independently of each other, construct colonies of simple nests. Beginning of the first social instinct. (*Andrena, Anthophora, Chalcidoma, Osmia*, etc.)
- Females construct isolated single nests. (*Prosopis, Osmia papaveris*, etc.)

According to the Severins and Hartung (79), the melon fly (*Dacus curcubitae* Cog.) oviposits in the stem, petiole, flowers and fruit of pumpkins.

Herrick (33) reports that the apple pest (*Xylena antennata*)

deposits its eggs in the leaf-scars before the leaves appear. He finds that, in confinement, *Ypsolophus pometellus* oviposits in the latter part of May.

Emery (22) discovered that *Simulium vittatum* breeds only in running water. The female attaches strings of 200 to 300 eggs to the rocks. There are three broods a year.

Bloeser (8) states that *Siphona plusiae* deposits one or more eggs on the outside of the Phrygnidian larva.

Welch (100) reports that the fly *Hydromyda confluens* Loew. constructs a gall on the submerged petiole of the water lily. He thinks the fly crawls down the stem and oviposits beneath the water.

Palmer (67) describes the laying habits of certain lady beetles.

FOOD PROCURING AND DEFENSIVE INSTINCTS

Campion (14) describes the feeding behavior of some dragon flies; Coad (16) of the boll-weevil and Houser (37) of *Conwentzia hageni*.

According to Bloeser (8) the larva of *Siphona plusiae* penetrates the body wall of the Phrygnidian larva and feeds upon its entrails. In ten days it is mature.

Branch (10) asserts that *Entylia sinuata*, a Membracid, feeds on the thistle (*Cnicus altissimus*).

By capturing flies and removing their prey from them, Bromley (11) has made a careful study of the food of eighteen species of Asilidae. He gives a list of prey that covers nearly six pages.

Emery (22) finds that the buffalo gnat (*Simulium vittatum*) will bite before ovipositing.

Girault (26) deprived half grown ant lion larvae of food for twenty-five days and found them still alive.

Guyénot (28A) found that the little fruit fly (*Drosophila ampeliophila*) develops normally when fed on sterilized yeast.

Heath (32) records an instance of a phalangid drinking milk.

The investigations of Hewitt (34) show that the dung fly *Scatophaga stercoraria* L. destroys large number of flies, especially Muscoid flies, by seizing the victim with its legs and piercing the neck with a thrust of the proboscis from below. After a moment's sucking, the fly is turned over and the proboscis thrust between the abdominal segments.

In another paper (35) he states that he could not get the

stable fly to bite until twenty-four hours after emerging from the pupa. [Mitzmain got them to bite at the end of eight hours.] Usually it feeds not oftener than once in twenty-four hours.

Hueguenin (41) informs us that a Noctuid moth (*Heliothis dispaceus*), which feeds on the tar weed, also feeds on the larva of *Pontia rapae.*

Isely (43) reports that the young of all the Eumenidae studied by him feed on the plant-feeding larvae of other insects.

King (47) finds that the mite *Gemasus immanis* Berl. feeds on Oligochaetes. Truessart claims that *Molgus littoralis* feeds on *Collembola*; but King could not induce this mite to do so. He found it feeding on living Diptera.

Merrill (60) found a Clerid larva eating the caterpillars of the codling moth. Palmer (67) finds that the amount eaten by the larvae of the lady beetles varies with the weather and the size of the larva; and that the quantity eaten by the adult varies with the weather and the egg-laying activity. None feeds on vegetable matter; all eat plant lice.

The Severins and Hartung (79) find that the melon fly (*Dacus curcibitae*) feeds upon the cucumber, egg-plant, kohlrabi, musk-melon, pumpkin, squash, string bean, tomato, watermelon, wild cucurbit, mango, orange (?), and papaya. They feed from sun-rise until 10 A. M., and rest during the hottest part of the day.

Venerables (91) finds the adult saw-fly *Tenthredo variegatus* feeds upon small Dipterous insects.

According to Welch (100) the young of *Hydromyza confluens* Loew. feeds on the waterlily.

Williams' investigations (103) show that the larva of the tiger beetle, *Amblychila cylindriformis* Say, comes to the surface at night and feeds on a variety of insects. It rejects distasteful ones, sometimes relinquishes an edible insect that it cannot subdue, and is occasionally overcome by its intended prey.

In another paper on solitary wasps, Williams (102) states that *Harpactus gyponae* stocks its nest with *Gyoina cineres*, a Jassid; that *Mimesa argentifrons* stocks its nest with *Athysanus exitiosa*, another Jassid; and that *Priononyx rufiventris* feeds its young on several species of short-horned grasshoppers.

In the following table Williams (101) has condensed much of

the information gleaned from his investigations of the food habits of the Larridae of Kansas.

TABLE TO SHOW THE PREY OF THE LARRIDAE

Wasp	Prey	Order to which prey belongs
Larra americana	Gryllidae	
Larra anathema (Europe)	Mole crickets (Gryllidae)	
Notogonia agentata	Immature *Gryllus* (Gryllidae)	
Larropsis divisa	*Ceutophilus* sp. (Locustidae)	
Tachytes abdominalis	Immature Tettiginae and Acridiinae	
Tachytes distinctus	Various Melanopli, *M. ferum-rubrum,* usually immature; *Ageneotettix deorum,* mature (Acridiinea and Tryxalinae)	
Tachytes fulviventris	Mature *Alpha crenulata* (Tryxalinae)	
Tachytes harpax	*Niphidium brevipenne* (Locustidae)	
Tachytes mandibularis	*Niphidium* and im. *Orchelimum*	
Tachytes mergus	Immature Tettiginae	Almost exclusively Orthoptera; the two exceptions are. Lepidoptera and Diptera.(*)
Tachytes obductus	Immature Tettiginae	
Tachytes obsoletus (Europe)	Young Oedipodinae	
Tachytes pompiliformis (Europe)	Immature *Gryllus rufus,* grasshoppers (*Chaiptusr*); lepidopterous larvae	
Tachytes rufofasciatus	Immature *Melanoplus cyanipes,* mature and immature Melanopli (Acridiinae)	
Tachytes tarsina (Europe)	Immature Acridiinae	
Tachysphex fusus	Immature Melanopli (Acridiinae)	
Tachysphex hitei	Immature Litaneutria minor (Mantidae)	
Tachysphex panzer (Europe)	Acridiinae	
Tachysphex plenoculiformis	Immature Traxalinae	
Trachysphex propinquus	Mature *Alpha crenulata, Ageneotettix deorum* and *Mestobregma kiowa*; immature *Opeia* sp. (Tryxalinae and Oedipodinae	
Tachysphea quebecensis	Immature Acridiinae	
Tachysphex semirufa	Immature *Melanoplus spretus*	
Tachysphex tarsatus	Immature Acridiinae, Tryxalinae and Oedipodinae	
Tachysphex terminatus	*Chortophaga viridifasciata,* immature Tryxalinae	
Trachysphex texanus	Immature Oedipodinae (Diptera)*.	
Lyorda subita	Nemobius; small crickets (*Gryllidae*)	
Plenoculus apicalis	Mature and immature Atomoscelis sp. (Capsidae)	Hemiptera. Exceptions: Orthoptera and Arachnida (†)
Plenoculus peckhami	Immature Pamera sp. (Lygaeidae).	
Niteliopsis fossor	Immature Oedipodinae†	
Niteliopsis inerme	Immature Capsidae	
Miscophus spp. (Europe)	Various small spiders, Epeiridae†	

Miss Alice Noyes (65) has made a careful study of the net-spinning Trichoptera of Cascadilla Creek. She confirms Siltala's statement that the food of *Hydropsyche* is both animal and vegetable. In the fall and winter diatoms form the bulk of their food; in the spring and summer animal food predominates. The members of the family Polycentropidae have an animal diet. *Chimamba alterrima* of the family Philopotamidae, feeds exclusively on plants. She makes the following conclusions:— 1. Many forms construct their nets only at night; but Hydropsyche spins by either night or day. 2. Two and a half to three hours is the average time required to weave a net. 3. Different species build similar dwellings. 4. Unlike the orb-weaving spiders, they do not spin preliminary construction threads. 5. There is no definite order followed in spinning the threads. 6. The mouthparts, not the tufts of hair on the anal legs, are used to remove particles from the nets. 7. Its front legs and mandibles are used for seizing and holding in place until fastened any bits that the insect intends to weave into the net. 8. It is never too intent on its weaving to pick up bits of food that become entangled in the nets. 9. Food captured in the net is dragged inward, killed and swallowed whole.

HIBERNATION

Houser (37) states that *Conwentzia hageni* hibernates in the larval stage.

Palmer (67) says all lady beetles hibernate in the adult form.

F. E. Lillie (48) thinks that some individuals of the monarch butterfly hibernate in the adult form, although she could not obtain confirmatory evidence of this. Indeed, all attempts to induce them to hibernate by keeping them in a cool, dark place failed; but in May she found adults with unfrayed wings.

King (47) does not say that the mite *Bdella longicornis* hibernates; but he states that it constructs a web in which it apparently spends the winter.

Baumberger (4) reviews, at length, the literature on hibernation of insects and reaches the following conclusion:—" 1. That temperature is but a single factor and not necessarily the controlling one in hibernation. 2. That hibernation is usually concomitant with overfeeding and may be the result of that condition or the result of accumulation of inactive substances

in the cytoplasm of the cell due to the feeding on innutritive food. 3. That the loss of water which is general in hibernation probably results in a discharge of insoluble alveolar cytoplasmic structures which have accumulated and produced premature senility with an accompanying lowering of the rate of metabolic processes. 4. That starvation during hibernation together with this loss of water may result in rejuvenation, when aided by histolysis, and in increased permeability. 5. That this rejuvenated condition and increased permeability, will, if stimulated to activity by heat, permit pupation in codling moth larvae, which in this case is the termination of the hibernating condition."

LOCOMOTION

Branch (10) relates that *Entyla sinuata*, a Membracid studied by him, exhibits no jumping activities in its nymphal stages.

The Severins and Hartung (79) tell us that the nearly full-grown larvae of the melon fly (*Dacus curcubitae* Coq.) exhibit a jumping activity which is never seen in the younger stages. The insect curls its body into a circle with its jaws attached to the tip of its abdomen. Then, by suddenly relaxing, it springs six or eight inches into the air.

Becker (5) describes a rather interesting migratory procession of the larvae of the fungus gnat (*Sciara congregata* Johannsen). Such a procession was observed June 6, 1912 and again July 16, 1913. At first glance it resembled a dead snake. The procession observed in 1912 was five feet long and tapered toward each end from the middle, which was three inches wide. There were several layers of larvae, tapering from eight deep in the middle to each extremity. The whole procession was moving forward; but the maggots on top moved much faster than those on the bottom, hence the insects of the upper layers were constantly advancing beyond the front, to be immediately covered by others coming from the rear. In its wake the procession left a trail resembling that of a snake. The procession of 1913 was only three feet long.

ECOLOGY

By exposing laboratory animals to controlled stimuli similar to those of their natural habitats, Shelford (81) has been able to analyze the behavior of animals forming communities and

has reached the following conclusions:—" 1. The animals of a community are in agreement in the reaction to certain intensities of two or more factors. These reactions may be used to designate them. Thus the rapids community may be designated as litho-rheotactic, meaning that the animals are arranged with reference to current and stones of considerable size. 2. Animals living in the same or comparable situations within the community habitat are in agreement and the animals of different situations react differently to these additional factors. Similar differences are the physiological basis of strata and consocies though the smaller number of species make the latter not easily distinguishable here. 3. Single species found in any community occur in other situations where they are governed chiefly by stimuli towards which there is not agreement of reaction throughout the community to which they primarily belong."

Wolcott (104) discusses the ecology of the parasitic wasp *Tiphia inornata*.

See McDermott under mating instincts.

DISEASE SPREADING ACTIVITIES

The papers of Graham-Smith (27), Harms (30), Lloyd (49,50), Ludlow (54), Riley (74) and Webster (95) will be of interest to physicians.

Zetek (106) has demonstrated that the typhoid fever spreading fly visits houses 2,500 feet away from the feeding places of its larvae.

Three theories have been proposed to account for the spread of pellagra: (1) the zeistic theory, based on the work of Ballardini, which appeared in 1895, which claims that it is a poisoning due to the excessive use of the products of corn; (2) Mizell's theory, proposed in 1911, which holds that it is poisoning due to the use of cotton-seed products; Sambon's theory, dating from 1910, which holds that it is spread by the sand-fly. Sambon bases his theory upon the following statements: (1) the endemic action in Italy has remained the same since the disease first appeared; (2) the season of recurrence coincides with and fluctuates with the season of the appearance of the adult sand-fly: (3) in the center of infection whole families are attacked simultaneously; (4) in non-pellagrous districts the disease never

spreads to others on the advent of pellagrins; (5) in families moving into non-pellagrous districts, children born in the former district are pellagrous, while others are not; (6) the disease is not hereditary; (7) it is not contagious. The advent of pellagra in Kansas gave Hunter (42) an opportunity to conduct a series of experiments which yielded the following results:—"(1) the number of sand-flies is directly proportional to the number of cases of pellagra; (2) the appearance of the cases of pellagra is coincident with the principal broods; (3) just succeeding the time of the principal broods the flies seem to bite more vigorously; (4) sand-flies which have fed on human blood live several days longer than those which have not been so nourished, thus favoring an incubation theory for a parasite, if such there be; (5) pellagra, thus far in Kansas, has appeared almost entirely in one restricted locality; of nine cases recorded last year five were traced back to one town; in this region flies are widely distributed; (6) no direct evidence has yet been found which would in any way warrant any conclusion with reference to an association of the sand-fly in the determination of the etiology of pellagra." Hunter hopes to continue his researches until the problem is solved.

PARASITISM

Cummins (18) describes a sarcoptid mite of the cat; Howard (37) several mites of the gypsy moth; and Bloeser (8) a hymenopterous hyper-parasite of *Siphona plusiae* Coq.

Triggerson (85) gives a list of the numerous parasites of *Dryophanta erinacei*.

Isely (43) tells us that the Eumenidae of Kansas are parasitized by the Bombilidae, the Tachinidae, the Ichneumonidae, the Braconidae, the Mutilidae, the Myrmicidae and the Asilidae; but that the most persistent parasites belong to the Chrysididae. He believes that the turrets constructed about the entrances of so many burrows of this group of insects are to prevent the entrance of parasites.

Muir (61) discusses the effect of parasites on the struggle for existence.

Fabre (23) describes the parasites of the mason-bees of his part of France and states that he does not believe that parasitic habits result from a love of inactivity; for he finds that parasites

work hard. The parasite *Stelis* must break through walls as hard as concrete to deposit its eggs.

Waterson (94) discusses the bird-lice of five species of English auks. In addition to a parasite peculiar to it, each often has one or more other parasites. He has epitomized his conclusions in the following table.

	Uria troile	*Alca torda*	*Fratercula arctica*	*Uria (Cepphus) grylle*	*Mergulus alle*	*Rissa tridactyla*
	11 birds	6 birds	6 birds	11 birds	10 birds	1 bird
D. acutipectus, Kell.	....	....	1 x (6)	....	....	....
D. calvus, Kell.	2 x (11)	....	1 x (2)	....	....	x (S)
D. celedoxus, N.	1 x (2)	1 x(6)	x(2)	....	....	Solitary female with numerous examples of *D. lari*, D.
D. megacephalus, D.		x(1) (S)	....	x(11)	....	
D. merguli, D.	x(1) (S)	....	....	....	x(10)	
D. icterodes, N.	....	x(1)(S)	....	....	1	....
D. cardiceps, P.	....	....	....	....	x(1)(S)	....

An x denotes the occurrence of *Docophorus* on bird species. The number in brackets indicates how often the parasite has occurred on the host species.

The long brackets with their numbers show how often and how many species have occurred together on an individual host.

(S) = straggler.

Thus, column one reads: "Of *Uria troile*, 11 birds have been examined and on all *D. calvus* has been taken. In two cases *D. calvus* has been found with *D. celedoxus*, and once with *D. merguli*. This last, however, seems a case of straggling.

SOUND PRODUCING ACTIVITIES

Regen (72) mentions the enticement of the female of a cricket (*Gryllus campestris*) by the stridulations of the male.

Mrs. Comstock (17) discusses, in a popular vein, the stridulations of crickets and gives directions for keeping the insects in confinement.

Aubin (2) has performed some experiments which cause him to assert that the high-pitched note produced by flies is due

neither to the vibrations of the wings, nor to the pulsations of the thorax, nor to special modifications of the occlusor apparatus of the stigmata, nor to movements of the halteres; but, to a special sound-producing apparatus which is situated, on each side of the thorax, near the base of the wings. This consists of a membrane-lined depression which is traversed diagonally by two ridges or ribs. When the wings are vibrated rapidly a chitinous structure on the base of each strikes against one of the ridges of the apparatus just described and induces the membrane to vibrate. This produces the high pitched sound we call buzzing. The following results of his experiments on the drone-fly (*Eristalis tenax*) seem to justify his conclusion:—1. The fly may be held in the fingers in any way but one without appreciably affecting the buzzing; press the shoulders of the wings to the body and the buzzing ceases immediately. 2. Each or all of the following parts may be removed without noticeably affecting the sound; halteres, squama, ante-squama, aulet and nine-tenths of the wing. If the entire wing is removed the sound ceases. 3. If the vibrations of the aulets be checked by a needle applied at the convexity of the chitinous part, the sound continues. 4. If, while the fly is buzzing, a needle is inserted between the chitinous part of the wing base and the ribs on the body of the fly, although the parts are uninjured, the buzzing ceases. 5. A minute spear of tissue paper inserted between the chitinous portion of the base of the wing and the ribs on the thorax subdues the sound. 6. If pins be so placed that, without injuring the wings, they prevent them from closing closer than 45° with the axis of the body, no buzzing is heard. Evidently this organ is of a higher order than the stridulating apparatus of the Orthoptera. Since a portion of it consists of a vibrating membrane, Aubin is inclined to believe that it is a sound-receptor as well as a sound-producer.

In the discussion which followed the reading of this paper before the Royal Microscopical Society of London, a Mr. Hopkins arose and stated that, eighty years ago, Burmeister had performed similar experiments which yielded identical results, and he wondered why Aubin had not cited Burmeister's experiments. At this writing, Burmeister's original paper is not accessible to the present writer; but, judging from the quotation made at the meeting of the society, Burmeister held that certain

folds connected with the spiracles were the cause of the sound. Unless the reviewer entirely misunderstands Aubin's words and illustrations, his apparatus is not connected with the spiracles. It does, however, seem strange that Aubin makes no mention of the work of Pemberton* which was reviewed in this journal about three years ago†. Pemberton, as a result of his experiments, insisted that there is no spiracular voice in insects and that the high-pitched notes of the Diptera and the Hymenoptera are caused by the striking of the bases of the vibrating wings against the sides of the thorax. Apparently he overlooked the ridges against which the wings impinge and the vibratile membranes connected with these ridges.

DURATION OF LIFE

Baumberger (4) found that, when exposed to constant temperatures, the longevity of insects varies, approximately, inversely with the temperature; when exposed to variable temperatures, a high or low temperature followed by medium temperatures favors a lengthening of life; exposure to a medium temperature at the beginning shortens life.

By crossing a short-lived strain of the fruit-fly (*Drosophila ampelophila*) with a long-lived strain, offspring were obtained which were longer lived than either of the parents. In the second generation some reverted to the short-lived condition. He thinks there is a physiological connection between the length of life and the coming into maturity of the germ cells.

Sanderson and Peairs (76) give a table showing the relation of temperature to the duration of life. The table was compiled from more than 400 separate experiments involving 390,000 individuals.

Phillips and Demuth (70) assert that the length of life of bees varies inversely with the amount of work they do; hence, to secure vigorous bees for the spring, the work to be done in winter should be reduced to a minimum.

Phil and Nellie Rau (71) have made extended studies of the longevity of the following Saturnid moths: *Philosamia cynthia*, *Telea Polyphemus*, *Callosamia promethea*, *Samia californica*, and

* Pemberton, C. E. Sound Producing Diptera and Hymenoptera. *Psyche*, vol. 18, pp. 82-83, 1911.

† *Jour. of Animal Behav.*, vol. 2, p. 396, 1912.

Samia cecropia. They tested both mated and unmated individuals. In all they studied 3,569 individuals. The following are some of their conclusions: (1) mating does not significantly shorten or lengthen the life of the male; (2) the unmated female lives longer than the mated: (3) a low temperature lengthens the life of *S. cecropia* and of *T. polyphemus*.

MISCELLANEOUS

Shelford (81) discusses the importance of evaporation in insect behavior.

1. *Migration.* Lillie (48) records the well known fact that the monarch butterflies of Minnesota and of New York migrate southward in vast swarms each fall; and Davidson (19) discusses the migration of certain plant lice.

See Becker under locomotion.

2. *Pain.* Weiss (97) reviews the arguments that have been produced as proof that insects do not feel pain and concludes that "The evidence for assuming that insects do not suffer acute pain is not by any means complete. We simply do not know and have no reliable means at present of finding out."

3. *Pollenization.* Mrs. Howard (38) has experimentally proven that bees are needed to pollenize certain plants. She covered 100 clover blossoms with netting and left 100 exposed to the bees. From the uncovered blossoms she obtained 2,720 seed; none of the covered blossoms produced seed. Of 2,586 covered apple blossoms only three matured.

4. *Sleeping habits.* According to Beutel-Reepen (7) the males of several species of solitary bees spend the night congregated in large clusters.

Williams (102) states that large groups of the males of the wasp *Priononyx thomae* spend the nights and unfavorable weather on the weeds.

Frohawk (24) describes the sleeping habits of the butterflies of the family Lyncaenidae.

5. *Temperature.* In an extended study of the temperature of the bee-hive, Gates (25) discovered that, even in cold weather, the bees are neither torpid nor semi-quiescent. There is a constant interchange of individuals between the outside and the inside of the cluster. Even in the coldest weather, they groom and comb one another.

MEMORY AND ASSOCIATION

Beutel-Reepen (6) believes that bees have a memory picture of the environment which guides them home.

Fabre (23) insists that it is not memory, but, a special sense which guides insects home.

Hudson (39) gives a short note on the memory of a Pompilid wasp.

Lovell (51) says; " Experiment and studies of the honey-plants show that honey-bees learn from observation and are guided by the memory of past experience. Flowers rich in accessible food supplies receive numerous visits, but if for any reason the flow of nectar suddenly ceases the bees immediately discontinue their visits."

See Lovell under visual sensations.

TECHNIQUE

O'Kane (66) describes the construction of an outdoor insectary, with a conservatory roof, which has screen sides for summer and glass sides for winter.

Shelford (8) discusses the importance of using atommeters in studying insect behavior.

Wolff (105) discusses methods of investigating the temperature reactions of butterflies.

Mrs. Comstock (17) redescribes a method, well known to students of insects, of keeping crickets in large lamp chimmeys resting in flower pots.

Phillips and Demuth (70) describe a method of investigating bee hives by means of electrical thermometers.

Draper (20) has devised a convenient live box for studying insects under the lowest powers of the microscope. A piece of glass tubing one-third of an inch deep and two-thirds of an inch in diameter is cemented to a standard microscopic slide. A circular piece of glass, of larger diameter than the cell, serves as a cover. Near the circumference of this cover and equispaced, three pins are attached to the underside. The collar by which each pin is attached to the cover prevents it from touching the top of the cell and thus insures ventilation. A false bottom permits regulation of the depth of the cell.

Baumberger (4) describes a convenient net for securing large quantities of live insects. The net is constructed in the follow-

ing manner: "A strong piece of iron wire, three feet, eight inches long, is bent into a circle with one foot diameter—the ends are then bent at right engles so as to lie adjacent and parallel to each other. The ends are inserted into the small end of a six inch ferule and soldered fast. A short two foot handle will be found best for sweeping. The net consists of white muslin—a conical bag about eighteen inches deep. The tip is cut off where the circumference of the bag measures about three inches and is replaced by a cloth bag four by six and a half inches. This small bag is sewed to the point at which the circumference of the large net is four inches, thus, leaving a sleeve which hangs down into the small bag—this small bag will just hold a quarter pound paper bag. The sleeve of the large net fits into the paper bag. When filled from a minute's sweeping, the paper bag is pinched at the opening, taken out of the net and placed in a botanical can. Upon the return to the laboratory the bag is opened at a well lighted window and the contents picked over for specimens."

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LITERATURE FOR 1914 ON THE BEHAVIOR OF VERTEBRATES

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VISION

Mammals.—Both Bingham (3) and Johnson (15) reply to Hunter's criticism of last year, in which he insists that form must be considered as a part of a pattern—that the stimulus object is seen against a visual background. The former urges first, that his apparatus was in a dark room which enabled him to control conditions of setting and second, that a distinction must be made between form and shape, i. e., two similar triangles, the one upright and the other inverted, would be alike in form but differ in shape. In his experiments he got a relatively low per cent of correct choices when the triangle was inverted; obviously, then, form was not the basis of choice. The perception of shape, for Bingham, is based upon an unequal stimulation of different parts of the retina.

Johnson argues that to change, as Hunter suggests, the alleys in the Yerkes' experiment box to hollow cylinders or triangles would also change the tactual and probably the olfactory qualities. Admitting that the background changes according as the stimulus object occupies the right or the left position respectively, he insists that if the stimulus form is as effective in one setting as in the other the conclusion is justified that the animal is really reacting to the constant form difference and disregarding the variable "pattern" difference.

The best articles on vision in the year 1914 are those of Johnson, beginning his series on Pattern Discrimination in Vertebrates (16), (17). The first paper deals with the standard methods of studying vision, the elementary problems in pattern discrimination and the apparatus and methods. The author defines pattern discrimination as a discrimination between visual fields equal in outline, area and average brightness and differing only in the disposition of their brightness. Four

problems are then outlined: (1) the stimulus threshold for striation, i. e., the width of the individual bands on one field to insure discrimination between it and another sensibly uniform field; (2) the threshold difference for size and conversely for number of individual bands; (3) the difference threshold for direction of bands; (4) the difference threshold for contrast which is really the threshold for brightness.

To produce the pattern two glasses were ruled with fine opaque lines so that the width of the lines and the clear spaces were equal. When these plates were rotated over each other there was shown a series of dark and bright bands of equal width. It is Cobb's apparatus slightly changed. With this was used a modification of the Yerkes—Watson double photometer box. The whole apparatus is excellent in conception and control, but for the exact details the reader must consult the original papers.

In attacking the first problem mentioned above, Johnson used a series of black and white horizontal bands of equal width with respect to each other but whose absolute width could be varied from one which was invisible to one which was plainly visible without changing any other factor. The task set was to distinguish this pattern field from a plain field having the same area, form, range of wave lengths and luminous intensity. The subjects used were dogs, monkeys and chicks. The details of the experiments are full of interest. No positive results were obtained from the dog as his behavior showed no sensitiveness to differences of detail in visual objects. The experimenter, however, reserves his conclusions on this subject. The visual acuity of the monkey was very like that of the human subjects used for comparison. The acuity of the chick was about one-fourth that of the monkey. The author raised further questions as to the method of experimentation the most significant of which, it seemed to the reviewer, was that relating to the optimal distance of the test field from the animal. The distance used in the work reported was, uniformly, 60 cm.

In some experimentation not nearly so well controlled as to the different factors involved, Szymanski (35) reports some work on the learning process in white rats. The apparatus consisted of three connected parts, but, as parts one and two were so very simple and gave such inconclusive results they

may be neglected. In the third part, the animals were required to go to the right or to the left according to a visual clue. Lamps of 10 and 2 c. p. were used as stimuli. The temperature was controlled. After 30 trials punishment was introduced and after 50 trials the 2 cp. lamp was discarded and the discrimination was made between the 10 c. p. light and darkness. The rats had from 93 to 109 trials and only 2 out of 14 animals learned to follow the light. These two animals made percentages ranging from 60 to 100. In five other instances the percentages were rising, although the fact is not mentioned, and probably further trials might have trained these also as Foley's work with sparrows, reported below, shows. The work was stopped too soon. One animal persistently chose the dark way. Many set up position habits. Numbers 4, 5, 13 and 14 went three times as often to the left as to the right and number 12 went four times as often to the right as to the left.

"The understanding of an organism" the same author says, (34) "is won through an analysis of its motor activities." This analysis falls into two chief parts: first, the conditions which influence the general motor activity positively or negatively—conditions which may be outside or may lie within the organism and second, the study of the organized movements going on under the influence of determined and directed stimuli. "In reality," he says, "the course has been reversed and investigators have begun with a study of organized activities and only here and there have sought to clear up the variability of the reaction to a determined stimulus by reference to the changing conditions of the organism or of the environment especially the temporal environment." By means of a bit of apparatus which is called an aktograph, he records the activities of a series of animals through the entire course of a series of days including days chosen at different times of the year. The apparatus was so arranged as to connect with a Marey tambour and make a kymograph tracing. Among other animals white and gray mice were used. No division of activities dependent upon light and darkness was seen in these animals. The white mice showed 16 periods of activity averaging 45 minutes each, the gray 19 such periods averaging 37.9 minutes each. These periods were fairly evenly distributed between night and day. He says, "It appears as if the division of rest and activity periods should

depend upon the preponderance of this or that sense in the life of the species. If the eye plays the chief rôle in the life of the species it is light which regulates the relations of rest and activity; if other senses have the preponderance, smell, hearing, kinaesthesis, these are the factors which lead to a different division."

Amphibians.—Laurens (19) investigated the reactions of normal and eyeless amphibian larvae to light. The forms which he used were *Rana pipiens*, *R. sylvatica* and *Amblystoma punctatus*. Neither normal nor blinded frog tadpoles gave any response to light stimulation. The behavior of Amblystoma, however, was different. Both normal and blinded individuals were found to be positively phototropic. These reactions, as proved by operative surgery, were not due to direct stimulation of the central nervous system but by stimulation of nerve terminals in the skin.

Fish.—More work on the color adaptations of fish has been done by Freytag (6). He used *Phoxinus laevis*, von Frisch's best subject, and tried it over many backgrounds. His experiments lasted a year and he used in all 100 animals. These animals were described minutely before and after the experiments and sometimes they were kept for 24 hours on the same background. There were always control animals. As a result of this work Freytag thinks that the adaptations are to brightness and not to color at all. There is no doubt he says that the brightness affects the animals, but no law can be formulated. Not infrequently was there no change and quite as frequently was the change in the opposite direction from what was to be expected. The yellow and red markings showed very inconstant changes and never was yellow or red the rule. On the other hand these colors were often seen when the fish were over other colors or over gray. He thinks the changes which do occur are not a response to background alone but are due to other conditions as well. The enemies of the fish do not all come from above. It is quite as possible that the adaptation may be to the brightness of the water in which it swims. None of the work speaks for a color sense for Pfrille.

Two other investigators (9) in the main confirm the findings of von Frisch.

The aktograph records of Szymanski (34) showed that the periods of activity of the fish were regulated by light. They began about one hour before sunrise and ended about one and one-half hour after sunset.

Birds.—Light discrimination in the English sparrow was the object of Tugman's (37) experiments and the main attempt was to find the threshold of brightness. The Yerkes-Watson brightness apparatus and experiment box was used. The birds were kept in darkness before the beginning of the work. Correct choices for two days (30 trials) were counted as a correct discrimination and then the difference between the standard .098 and the variable was decreased and the tests were resumed. The discrimination differences attempted ranged from .096 to .009 and the estimated thresholds for four birds were, .015, .035, .03, .022 c. p. The estimated thresholds for some human subjects were .013, .009, .013 c. p. The author says, "One of the most striking facts is the very large number of trials necessary to bring the animal to the threshold. The three animals for which the threshold was determined averaged 2,420 trials each. For the discrimination of the lowest threshold they averaged 480 trials each; one of them discriminated only after 615 trials.

As will be seen we are at last getting some well controlled work on sensory discrimination in animals. The first of the studies from the Franklin Field Station which Yerkes describes in the same journal (41) is reported by Coburn (4). He gives a preliminary study of the crow's ability to discriminate brightness, size and form. In the investigation he used but two birds. The apparatus was a modified form of the discrimination box used by Breed and Cole in their study of the visual reactions of chicks and the stimulus plates were the standard plates of the Yerkes-Watson apparatus. Both method and apparatus are carefully described in the report. The crows learned to discriminate between an opal flashed glass and an opal flashed glass backed first by two milk glasses, second, by one milk glass; third, by a sheet of paper. These roughly indicate the crows' ability to distinguish differences in illumination. Then they learned to discriminate between a 9 cm. and a 2 cm. circle; between a 5 cm. and a 3 cm. circle and between a 3 cm.,

and a 2 cm. circle. Another series of experiments, however, showed that the crows were reacting not to absolute size but to relative, i. e. to the larger circle. They also learned to distinguish a circle from a triangle and from a hexagon under conditions where form was the only constant factor.

Szymanski's (34) aktograph curve for birds shows a high degree of activity for the morning hours. In the hours immediately after noon the activity decreased and then with great constancy rose again just before the beginning of the night rest. In this respect it resembles the waking (day) curve of men given by Helpach. The movements of the birds can be inhibited not entirely but greatly in intensity and also in general nature by darkness.

SOUND

Mammals.—There are only three papers to report on auditory sensitivity in connection with vertebrates this year. Shepherd (31) using the method which he had previously employed with raccoons and monkeys investigated sound discrimination in cats. The notes were blown on an ordinary harmonica or sounded on a piano. The animals were to climb up in a cage for food at one note or refrain from climbing when another was sounded. He thinks that he found positive proof of pitch discrimination as well as discrimination of intensity in noise. The constant presence of the experimenter makes possible other clues and renders these results doubtful as Johnson's work with dogs has shown.

Considering the work mentioned above and other similar studies the following report by Morgulis (23) seems almost incredible yet perhaps our apparatus or methods are at fault. He discusses clearly and concisely the Pawlow method and makes a brief report on Usiewitch's study of the auditory reactions of the dog by this method. He found an auditory faculty much keener than man's. The dog perceived one-eighth of a tone and tones of a frequency of vibration quite beyond human reach. He found absolute memory for sounds and his dogs could distinguish the shortening of an interval by less than one-fortieth to one-forty-third of a second.

Hunter (12) has less startling results in a report which he makes upon some studies of the auditory sensitivity of the white rat which are now in progress at the University of Texas.

A 512 c′ fork was used for the tone stimulus and the alternate noise stimulus was hand clapping. The animals were to go to the right or to the left respectively at the stimulus. Under the conditions the errors steadily decreased but when the tone was withheld the reaction remained the same proving that the animals were reacting to noise only. None of seven rats in 700 trials learned to react to tone. There was also failure to discriminate between different intensities of c′. Many noises were substituted successfully for hand clapping with another set of animals. Interrupted tones gave no better results. The author concludes that either the rats cannot hear c′ or that their sensitivity to this tone is extremely slight.

OLFACTION AND CHEMICAL SENSITIVITY

Mammals.—A note on the supposed hunting response of the dog by Johnson (15) is a brief but interesting bit of analysis of some of the theories adduced to account for the ability of the dog to trail his master or track his prey.

Amphibians.—Risser (27) studied the toad in its reactions to natural or artificial food odor in living or dead animals. Odor streams were tried and the experiments were repeated in darkness. The species used was *Bufo americanus* Le Conte. His conclusions are that the visual is the sole stimulus which arouses the food response of the toad and that this is effective only when the food is in motion. Rejection of food, he thinks, is due to mechanical or tactual stimulation and the gustatory function is negligible. No positive conclusions are drawn as to olfaction yet he found it difficult to establish any connection between the seeking of food and inherent food odors. Odor streams caused definite motor activities which were proven by operative procedure to have an olfactory stimulus. The reactions which were inhibited by section of the olfactory tract were not affected by section of the trigeminal nerve. Tadpoles appear to use olfaction in discrimination of foods. The author says, "In the metamorphosed toad the visual stimulus is the principal and guiding factor in procuring food. Therefore it is inhibitory in relation to other stimuli and their resultant reactions."

Rapid modification of behavior was noted by Shelford (30) in experiments designed to test the sensibility of amphibians to

variations in the evaporating power of air. In this case the conditions were such as would tend to dilute or concentrate the plasma either in the peripheral sense organs or in the animal as a whole. Though associations are formed, Shelford says, they go hand in hand with and can hardly be distinguished from other type modifications * * * There is no reason to assume that associative memory is essentially different from the type of modification here described. * * * It seems probable that many of the simple problems of associative memory must be referred to the bio-chemist for solution."

Fish.—Shelford (29) also has published an elaborate bit of experimentation with different kinds of fish. They exhibited distinct differences in behavior in the presence of modified water. He inclines to the belief that the changes in activity are due to physiological conditions in many cases connected with CO_2 relations and do not necessarily involve associative memory at all. The stimuli which gave rise to the modifications most quickly are those most commonly encountered by the fish in water—a disturbance of neutrality either in the direction of acidity or alkalinity.

INSTINCTS AND HABITS

Mammals.—In the hope of coming to a better understanding of abnormal human sexual behavior, Hamilton (10) has made an excellent study of sexual behavior in monkeys. The observations included twenty animals mature, immature and eunuchs and were made under the varied conditions of confinement and free range which a California laboratory permits. For the many suggestive details the original paper must be consulted. The author regards behavior as an expression of reactive tendencies which have specific representation in structure. He says, "The essential factors in the behavior phenomena are (a) the action of a physiological process usually operating in conjunction with environmental forces, in the production of (b) hungers which impel the individual to manifest (c) activities, the particular types or modes of which are to be ascribed to (d) specific organic properties (reactive tendencies)." He recognizes three hungers which normally impel the macaque to manifest sexual behavior, viz: hunger for sexual satisfaction, hunger for escape from danger and possibly hunger for access to an enemy.

Lashley (18) gives us a note on the persistence of an instinct and Hahn (8) a popular account of the hibernation of certain animals. Among them are the bear, woodchuck and ground squirrel.

Amphibians.—The only article on the instinctive behavior of amphibians is that of Banta (1) who gives some interesting notes and careful observations of the mating behavior of wood frogs which he watched at Cut off Pond, Cold Springs Harbor.

Birds.—To observe the very first performance of the social activities of an adult one must rear the animal in isolation and then allow it, while under close observation, to come in contact with another animal. Craig (5) does this and gives an interesting account of the behavior of three male doves which he has thus brought up apart from their fellows. He concludes, among other things, that display behavior needs social stimulation; that the motor aspect of the sexual reaction is definitely provided for by inheritance but that what he calls the 'sensory inlet' is not complete and is supplemented by experience; and that one finds surprise, hesitation and even fear in the first performance of an instinctive act while ease, skill and intelligent adaptation are the gift of experience.

Another paper which deals with sexual reactions also is that of Huxley (13). He recounts in elaborate detail the very dramatic courtship or love habits of the Grebe. After describing the bird and giving its animal history, he turns to the real interest of the study—the relation of the sexes. (a) in the act of pairing, (b) courtship, (c) nest building, (d) the relation of different pairs, (e) other activities. In the discussion which follows, the author tries to explain what he calls the facultative reversal of the sexes in the act of pairing—a subject which is interesting many investigators at the present time—and he then elaborates a modification of the sexual selection theory which he calls mutual selection. He says, " Where combined courtship actions exist and a variation in the direction of bright color or strange structure occurred it would make the actions more exciting and enjoyable and those birds which showed the new variation first would pair up first and peg out their 'territories' for nesting before the others could get mates." * * * As to the courtship activities he says, " These actions are much too elaborate and

much too specialized to be considered as the immediate outcome of any form of physiological excitement. They obviously have a long and complicated evolution behind them and as they can only be performed by two birds together there is nothing to account for them as they now stand but some such process as I have just sketched under the name of mutual selection. The second part of the paper gives in detail some of the material worked up in the first as well as some notes on various points not connected with the main interest of the study.

Pearl (26) gives us, in the seventh paper of his series, a discussion of the brooding instinct which is very much changed possibly under domestication and certainly very much curtailed under the methods employed at the Agricultural Experiment Station. He concludes, however, (1) that it occurs with greater or less regularity following periods of egg laying. (2) that it varies in intensity at different times in the same individual. (3) that it is not necessarily connected with any season and may occur out of breeding season. (4) that it is ordinarily but not necessarily preceded by the laying of a clutch of eggs. (5) that it is apparently closely connected with the functions of the ovary. although the precise nature of the connection has not yet been analyzed.

The flocking habits of migratory birds is the subject of Trowbridge's (36) paper. He analyzes the automatic protection which a large flock affords as follows: A single bird might be in error from (a) confusion with regard to proper direction of flight, (b) effect of heavy winds or thick fogs acting as a temporary confusing factor while migrating, (c) gradual deviation from the course due to unequal wing power. A large flock eliminates these causes of error to a large extent and the origin of the flock is probably due to the fact that it is protective. The errors are averaged by numbers. He does not attempt to explain the 'sense of direction' but rather the mechanism to avoid getting lost. Night migratory calls are discussed and the protective form of certain flight formations as *e. g.*, the echelon. This he thinks is not taken to prevent any interference but so that each bird may see both forward and to the side at the same time. Birds instinctively follow one another.

Some experiments in feeding humming birds which were continued for seven summers are described by Sherman (32).

The birds learned to sip sirup from bottles concealed in flower forms and from an unconcealed bottle fastened to a post. The amount of sugar taken by a bird per day amounted to 110 to 120 minims. From the behavior observations it seemed probable that the same birds were coming back summer after summer. They nested in a near by wood and only came to the garden for their food. All the birds which fed from the bottles were females.

Strong (33) studied the Herring Gulls both in their breeding places and in confinement at the University of Chicago and has written up his results in two papers and Tyler (38) has published some notes on the nest life of the Brown Creeper in Massachusetts.

LEARNING

Many of the studies in animal learning have been noticed under the head of the particular sense control which was involved. The articles are not so numerous as in 1913. Basset's (2) study of habit formation in a strain of rats of less than normal brain weight may be mentioned. The rats were some derived from experimental inbreeding at the Wistar Institute of Anatomy and Biology and their relative brain weight (relative to body length) was $6\frac{1}{2}$ per cent. less than that of their normal controls. Basset worked with several generations of these for over two years on maze and puzzle box problems and he used in all 62 inbred animals and 62 normal controls. Tests were made not only for learning but also for retention and for relearning. In all of the experiments the rats of lesser brain weight did poorer work on an average than did the normal control series. The inbred rats of the seventh generation worked less well than those of the sixth and those of the eighth generation not so well as those of the seventh. "It would seem," the author says, "although lessening brain weight had ceased after the fourth generation that the ability to form habits lessened progressively with successive generations of inbreeding. The writer nowhere urges that this lesser ability is due to the inbreeding *per se*.

Of a different type and far less well controlled is some work which is reported in a paper on learning and relearning which comes from the Bedford College for Women, University of London (20). The work was under the immediate control of

two students but was also used for class demonstration. As is clearly stated the work is a repetition of old problems and makes no pretence to originality. The straight and square mazes described by Yerkes in the Dancing Mouse were the mazes used and in addition a maze in five sections which was built for this experiment. There were only two mice used on this apparatus. Mouse 'M' learned the straight maze, then the same maze reversed, then the square maze, then this maze reversed and then relearned both of these mazes at varying intervals in their original positions. Mouse 'S' followed the same order, only it began with the square maze. Both learned the sectional maze, relearned it and learned it in reversed position. Many individual learning curves and much data are given. Three rats worked on two of Small's puzzle boxes. The general conclusions are as follows: (1) With renewed repetitions there is a steady advance in learning. This advance, however, bears no direct relation to the interval which elapses between one series of repetitions and another. (2) With sufficient repetition the successful response may become so "well known" as to be unaffected by the lapse of long intervals. (3) The successful response is developed in connection with the general meaning of the situation. The experiments do not warrant us in saying in what experiences this general meaning consists. Retention of it, however, is of even greater importance in influencing the progress of relearning on a subsequent occasion than retention of the series of successful movements. Thus the learning does not fall entirely under the law of habit. The successful movements acquired in learning one maze do not hinder the mice in learning another which demands a different series of turns; on the contrary, learning which takes place after practice on other work is more successful than relearning which follows on a period of idleness. * * * The influence of the general meaning of the situation is more marked in the learning of the puzzle boxes by the rats than in the learning of mazes by the mice."

The Elberfeld horses still continue to engage the attention of our friends across the water. Moekel (22) thinks the Mannheim dog's behavior much more spontaneous than that of the horses. Máday (21) attempts an elaborate analysis of the mental functions of man, their forms and the conditions which

evoke them and then examines the proof of the same in the Elberfeld horses. Piéron (25) whose ideas on the subject are a little more sane than those of some other investigators gives an excellent review of the situation with a very complete bibliography.

A careful report by Haenel (7) shows that the horses seem to have lost ground during the year. Krall attributes this to the almost unbroken succession of visitors and their many questions. Krall admitted that the vocabulary of Zarif had decidedly suffered and that many of the arithmetical operations which Muhammed formerly performed were now beyond him. Barto, the blind horse, which had previously acquired the foundations of arithmetic in a few days, had, in the summer, after five weeks vacation, forgotten it all, and learned it the second time with much greater difficulty than at first and had not yet acquired his former facility. All of the first horses which Krall undertook to train were teachable—had understanding as he thought. But during 1914 he had three horses from the stud of the King of Wurtemberg and after three or four weeks endeavor he was forced to confess that he could teach them nothing and had to send them back as unlearned as they came. He has similarly failed with a young female elephant. Those who were inclined, with Krall, to rate the intelligence of the horse very high wonder now if these horses have reached the limit of their ability. Others ask, is it not possible that the criticism which has been made upon these claims has influenced Krall so that clues which the horses could use in their training, possibly unconscious to Krall himself, are being excluded.

One of the best articles on the subject is a critical paper by Schroeder (28) which not only inquires into the proof of the facts but also into the philosophical and scientific implications of the theories which have arisen in their explanation.

GENERAL PAPERS

Besides these articles reported above there are others of a more general nature which do not properly belong under any of the above headings. Hubbert (11) discusses the value of units of time versus units of distance in learning. In the way of apparatus four graphic methods of recording maze reactions are described by Yerkes and Kellogg (40) which they designate

as (a) the direct method, (b) the simple reflection method, (c) the double reflection method of Watson and (d) the double reflection method of Kellogg. The authors discuss the advantages and disadvantages of each scheme and their paper is followed in the same journal by one by Watson (39) in which he describes his own recording device in greater detail. His circular maze is a maze so planned as to make it very easy to increase the complexity by adding new units, etc., and with this maze goes his excellent recording device.

A sympathetic description of the Pawlow method with animals is found in Morgulis' paper (24). The article is devoted chiefly to the neuro-psychical phases but the method with its implications is of interest to all who work with vertebrate animals.

Similarly the article by Carr (3a) on the Principles of Selection in Animal Learning will attract all who attempt to analyze animal behavior or to explain their mode of learning. It is impossible to summarize an article which is itself so compact. The author says, "Selection and elimination are the diverse effects of a single process or mechanism. All connections tend to be preserved; all develop in strength and functional efficiency during the learning process, but their development proceeds unequally. The unsuccessful tendencies are not eliminated in the sense of being torn out by the roots; they are eliminated only in the sense of not being aroused in that situation. The strongest and most prepotent tendencies of the group function first and dominate the situation. The successful act is selected because it finally becomes the most prepotent in the group; all others are eliminated, or better are 'suppressed' because of their lesser development in functional efficiency.

"The problem of determining the various principles of selection thus resolves itself into a search for those factors which favor the retentive development of the successful act at the expense of the many failures. These principles are relative recency, relative frequency, and relative intensity."

These principles are then applied in a careful analysis to three types of animal problems. The paper concludes with a brief comparison of these selective principles with that of pleasure-pain which has been advocated so frequently by others.

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WATSON'S "BEHAVIOR"[1]

E. L. THORNDIKE AND C. J. HERRICK

Professor Watson's "Behavior" is not only an admirable introduction to comparative psychology; it is also an important record of the methods and ideals of investigation approved by a leading investigator and a stimulating account of his views on the general problems of animal life and intelligence.

Examining it from the first point of view, one finds a clear and readable statement of representative problems, of apparatus and methods, of what is known and opined concerning instinctive tendencies, habit formation, imitation and other possible secondary sorts of learning, of the limits of educability, of the relation of human behavior to that of other animals, and of the sense-powers of animals. Every teacher of psychology who acknowledges the need of providing knowledge concerning animal psychology is in Watson's debt. With Washburn's book for the analysts, Watson's for the behaviorists, and both together for the ordinary matter-of-fact psychologist, the teaching of animal psychology should be notably efficient. It is interesting to note that animal psychology is now in a position to mete out to the anecdotal school the strongest form of denial—neglect. Watson, if I remember correctly, nowhere quotes or refers to Romanes or any of his like. This is probably wise, though pedagogically the contrast in question is one of the best beginnings for a student.

There are three topics which the reviewer at least wishes Watson might have included for the student's sake and one which might perhaps better have been left out. First, the behavior of the micro-organisms should, I think, have had a special chapter in addition to the incidental references made. Indeed some of these references are likely, as they stand, to be unintelligible to many students. Second, concrete cases of the phylogeny of behavior, such as Whitman's story of incubation

[1] Behavior: An Introduction to Comparative Psychology. By John B. Watson, New York, 1914, xii+439 pp.

or the course of the scratch reflex, with a discussion of the problems of tracing the growth and differentiation of behavior as a fact, seem to me among the most stimulating facts of animal psychology. The arguments concerning the causes of variation in general and the potency of sexual selection in general might well be omitted in favor of the more specific and more relevant concrete story of behavior's natural history in the world. In the third place, I regret the omission of a chapter concerning objective methods and results in *human* psychology. The student is likely, as Watson's book stands, to be left with the impression that mental chemistry—the analysis of conscious states into elements and the construction of cross-sections of a stream of consciousness out of sensations, affections, and other Wundtian myths—has been the regular, orthodox thing in human psychology. On the contrary, objective methods and results have characterized a very large proportion of the work of recognized psychologists for thirty years. Ebbinghaus' *Memory* and Cattell's studies of reaction-time, for example, are as 'behavioristic' or objective as Bassett's study of rats or Yerkes' study of frogs.

Watson has, throughout the book, freely joined to the description of the status of animal psychology a plea for rigorous control of conditions and steady aim at prophesy of behavior as a test of the truth of conclusions. One feels the zeal of the investigator for sound research and the faith of the scientific man in matter of fact control and prediction as the justification of science. There is also the healthy insistence that our eventual ideal must be an explanation of intellect, character and skill in terms of known neural mechanisms. All this, though perhaps somewhat over the heads of students, is healthy, and helps to make the book a truer picture of the status of animal psychology, whose workers have worked in comparative freedom from obscurantist conventions.

The third contribution of the book is the systematic expression of Watson's views of the folly of introspective analysis, the non-existence of centrally initiated processes, the relation of pleasure to afferent impulses from the erogenic zones, the adequacy of speech movements and other muscular responses to account for what is commonly meant by 'thought,' the structural unmodifiability of the neurones from soon after birth,

and the adequacy of frequency and recency to explain all the dynamics of learning. These views will interest psychologists even though they know or care little about the details of animal activities. It is, of course, impossible to do justice to them either in description or evaluation within the limits of these pages. In the reviewer's opinion all of them are important, but also, with one exception, are too extreme to be correct as stated.

Watson seems to me to neglect the facts that a human being can observe himself not only as he observes another human being but also by other avenues, and that this information about oneself, got irrespective of sense-organs, may well play some part in science. It is a minor part, but not necessarily zero. That "there are no centrally initiated processes" seems flatly false at its face-value, and, even when interpreted by a conservative understanding of Watson's account of implicit behavior—that is, of the procedure occurring in very long-delayed reactions—seems to imply that all the hundreds of millions of secondary circuits of associative neurones are doomed to inactivity except when stimulated within a half-second or so by sensory neurones. Perhaps I have misunderstood his position on this point. The limitation of pleasure to stimuli from the sex zones seems dubious in view of the apparently closer attachment of pleasure to tastes and smells and its apparent lack of any such rise and fall as the sex-zone sensitivities show. The doctrine that the neurones stay the same structurally from birth, or soon thereafter, is, I am aware, fashionable, but it is speculative, and the opposite speculation—that the terminal arborizations and collaterals of the neurones grow here and dwindle there—seems to me more in accord with known facts of growth, degeneration and regeneration. Theories of behavior should not pin their faith to either theory.

The doctrine that the 'successful' response is selected and associated with the situation, not because of its success, but because it has been made as a response to that situation oftener than any other one response, seems substantially identical with the similar doctrine of Stevenson Smith. The argument holds, as I have shown in discussing Stevenson Smith's presentation of it, only if by original nature the 'successful' response has nearly

as great a probability of occurrence as any other one. Watson, like Smith, neglects the common case of learning of the type:—

Situation	S,	Trial 1,	Day 1,	Responses	1, 2, 1, 1, 1, 2, 1, 1, 3, 1, 1, 4	(4 bringing food)
"	S,	" 2,	" 2,	"	1, 1, 1, 2, 2, 1, 2, 3, 5, 1, 4	(4 bringing food)
"	S,	" 3,	" 3,	"	1, 2, 1, 1, 6, 1, 3, 1, 4	(4 bringing food)
"	S,	" 4,	" 4,	"	1, 1, 2, 1, 4	(4 bringing food)
"	S,	" 5,	" 5,	"	1, 3, 1, 1, 4	(4 bringing food)
"	S,	" 6,	" 6,	"	1, 2, 1, 3, 4	(4 bringing food)
"	S,	" 7,	" 7,	"	1, 2, 1, 4	(4 bringing food)
"	S,	" 8,	" 8,	"	1, 4	(4 bringing food)
"	S,	" 9,	" 9,	"	4	(4 bringing food)
"	S,	" 10,	" 10,	"	4	(4 bringing food)

Here response 1 starts out with a frequency of 8 to 1 and yet loses in the end. Such cases are very common in learning.

I have registered these objections to Watson's views largely because it seems desirable to keep the general aims and methods of objective psychology distinct from the particular explanatory hypotheses of any one of us who are studying it.

In his emphasis on the prevalence of actual speech movements as the body, and perhaps even the soul, of thought, Watson seems to be following a much more hopeful hypothesis. Thought does seem to be in the beginning, as Cooley has said, "a species of conversation" and throughout life what many introspectionists call images of words are almost certainly often actual partial enunciations. The time-honored 'think bubble' experiment, for example, is not a test of the presence of kinesthetic *images*, but of actual movements—evidence of a kinesthetic image would be found rather if one *could* think of saying the word without moving the mouth-parts. Human behavior in thinking does consist of muscular responses, the sensations thereof, further responses excited thereby, and so on, to a much greater extent than the older "train of thought" metaphors suggested. A large residuum of thought that involves only intracerebral neurones does, in my opinion, exist, as witnessed in the mental manipulation of space relations in geometry, engineering, and the like, or sound relations in musical composition; but Watson has exposed a weak spot in psychology's neglect of the actual muscular action that goes on in thought and confusion of it and sensations due to it with kinesthetic *images*.

A reviewer of this book is presumably expected to make some estimate of Watson's contrast of the general merits of the

study of consciousness and the study of behavior, as means to the progress of science. Watson seems to me to offer the right criterion in *power of prophecy*. The proper criticism of the analysis of conscious states and synthesis of supposed conscious elements at which gifted followers of Wundt have busied themselves for a generation seems to be that these labors have so seldom enabled us to prophecy what any animal, human or other, would actually think or feel or do in even a dozen situations. Where we do find power of prophecy attained, we commonly find that objective study of what the subjects of the experiments have said or done has given it. The trouble seems to be, not that pure psychics, or the inner life of a man as he feels it, does not exist and give facts, but that it gives facts to only one observer, and that, first, we get on much better by using his *testimony* about these facts (which is, of course, his behavior, verbal or otherwise) by the ordinary methods of science than we do by leaving him to try to draw inferences from it in some more direct way. In fact, he himself does as well or better by reporting the inspections of himself which he makes without using his sense organs to himself by inner speech and the like and using them thereafter as he would use the reports of any other man. In the second place, these one-man, unverifiable observations do not work as well in science as observations made *via* sense organs which many of us can make together and which we can repeat.

Watson is probably right, also, in asserting that straightforward objective work has been more or less hampered by the fashion in psychology of attempting always to say something about some purely psychical fact. The protocols on the conscious accompaniments of reaction-time experiments, discriminations of sensory differences, and measurements of 'thresholds' of intensity, for example, it might be torture for Watson to write, collect or read; and if his book relieves future Watsons from being conscience-smitten at not contributing to knowledge of how a frog feels to himself when he croaks or what the stream of a rat's consciousness is as he scampers through the maze, it will serve thereby a worthy end.

In any case the spirit of psychology in America seems now to be in a healthy condition in encouraging individuals each to do the work he thinks best in the way that he thinks best, and

in judging work by the truth and usefulness of its results rather than by the orthodoxy of its presuppositions or methods. For students of the subjective side of the world by personal inspection of one's own inner life to regard their work as that of a psychological élite, pure-breds, untainted by physiology, sociology, psychiatry or education, would now be amusing rather than objectionable. For students of objective behavior to regard themselves as martyrs, heroes or prophets is now unnecessary.

E. L. Thorndike.

The writer has been asked to add some comments from the biological standpoint to Professor Thorndike's review of Watson's Behavior. It is a pleasure to do this, for Doctor Watson's biological training, wide reading and accurate scholarship are everywhere reflected in this work. There are only a few additional points where comment from the biological side suggests itself to me.

The first point is a very minor one, which suggests, however, some reflections of wider import. In commenting upon the backward condition of the anatomy and physiology of the nervous system, a number of interesting problems are suggested, such as the nature of nervous impulses, the processes which make for the adaptation of sense organs and the like. Then follows the rather disquieting statement, "In this day of advanced physiological and neurological technique surely the only difficulty in obtaining satisfactory answers to these questions is the lack of sufficient interest on the part of the men who are competent to carry out such researches."

The fact is that the number of researches directed toward such neurological problems is fairly large—far greater than one man who devotes his whole time to neurological work can master if he attempts any original work himself. Must we then infer that the fundamental difficulty is that so few of these numerous workers are really "competent to carry out such researches"? Possibly; but the real explanation for the relative sterility of so much of this arduous labor lies in the fact that the "advanced physiological and neurological technique" of today is wholly inadequate to open up most of the problems mentioned. "If the iron be blunt, and he do not whet the edge, then must he put to more strength." We need to whet the edge of our neuro-

logical endeavors by the acquisition of new points of view. The study of familiar facts in a new setting is often all that is necessary to point the way to entirely new methods of attack.

A review of neurological literature, especially in the field of comparative neurology, reveals a prodigious amount of research from which surprisingly few generalizations can be deduced which are of great interest to students of either animal behavior or human psychology. This literature has its own problems, in the solution of which it has not been wholly unsuccessful; but these problems have always been sharply circumscribed by the limitations of technique, not the least of which has been the failure of investigators in this field to make a correlated study of both the structure and the functions of their objects of research. Doctor Watson's recommendation that extensive programs of research be carried out with the cooperation of behaviorists, experimental physiologists and neurologists is a suggestion of constructive value. In short, while the technique of each discipline needs improvement, the greatest need is for a technique of cooperation.

In the discussion of instinct, biologists, behaviorists and psychologists all claim an interest. All behavior is complex, and it has been common for each student of animal life to select from this complex the particular factors which seemed best to fit into his own philosophical preconceptions and to use these factors only in formulating his conception of instinct.

In contrasting instinct and habit (p. 185) Doctor Watson clearly states the cardinal principle which alone can bring order out of the chaotic and hazy notions which are current. This principle is the sharp distinction between the innate and the acquired factors in behavior. All agree that a reflex is the function of an innate mechanism. Now when reflexes are combined, as we always find them in behavior complexes, the order and pattern of their combination may likewise be determined by the hereditary organization, or this pattern may be acquired during the individual life of the animal. In the former case we are dealing with a pure instinct; in the latter case with a pure habit. This is Watson's terminology. I would add, that, in any concrete example of behavior in a higher animal, both of these types are almost certain to be present, and so the particular act cannot as a rule be classified off-hand as instinc-

tive or habitual. The best that we can hope to do is to analyze the act into its elements and then determine which factors are innate and which are acquired.

It has been my conviction for several years that the term instinct has outlived its usefulness in science. All behavior of organisms can be classed under two heads. It is either the function of an innate mechanism and therefore determined by the hereditary organization (reflexes, 'instincts'), or else it exhibits new combinations of elements whose pattern has been individually acquired. Habit is only a terminal phase of this individual modifiability. Both innate and individually variable action are found in some measure in all organisms, and, as stated above, in almost every act of the higher animals; and a more detailed consideration of the relations of these two factors at the beginning of the discussion of instinct might profitably replace some of the discussion of moot questions of general evolutionary theory in Chapter V.

There is a third topic in Doctor Watson's book about which it may be presumptuous for a mere biologist to express an opinion, though it most assuredly has a biological aspect. The new school of experimentalists has sought to rescue the study of animal behavior from the slough of anectodage and uncritical anthropomorphism into which it had fallen and to establish it on the secure scientific basis of objective and verifiable observation. In this their labors have already been crowned with a gratifying measure of success, and the future promises still greater gains. In such a book as this one, the author, accordingly, does well to adhere strictly to the program which has been so abundantly justified by results and to limit his discussions to what is objectively verifiable, leaving quite out of account, observations and speculations about possible mental processes of men or other animals. This is a sound scientific procedure.

But when he goes further and says that because the phenomena of consciousness as introspectively experienced are irrelevant to his special program, therefore they are everywhere else irrelevant and negligible, he seems to have thrown out the babe with the bath, and the biologist should be the first to protest. The new psychology may perhaps be able to dispense with consciousness, but biology cannot do so.

One hesitates to utter his convictions on the last point, for he is certain to be misunderstood. But conscious processes are realities which cannot be ignored in a comprehensive scheme of things. They are, moreover, positive biological factors in human evolution; and the biologist can see no reason why they should not be observed in the only way open to him, namely, by introspection.

Is there not, therefore, abundant justification for including consciousness, as introspectively known, as one of the elements of human behavior (and inferentially of the behavior of some other animals also), and should not any comprehensive scheme of behavior studies include this factor for what it is worth? The fact that in the past the uncritical use of these data and of hypotheses based thereon has often led us astray is no justification for denying their validity and practical value when properly used. Whether in any given program of research it is expedient to use these data, is a quite different question, which must be decided on its own merits in each case.

C. J. Herrick.

DUNLAP'S "AN OUTLINE OF PSYCHOBIOLOGY"[1]

C. JUDSON HERRICK

At the present time there is an active demand for a brief untechnical introduction to the structure and functions of the nervous system adapted for the use of students of psychology and education who have no biological training. It is the purpose of this little book on Psychobiology to fill this need. Every experienced teacher will recognize that the difficulties in the way of such an enterprise are almost insuperable, and any intelligently directed effort in this field should, accordingly, be judged leniently.

There are nine chapters in Dr. Dunlap's work, of which one is devoted to the cell, one to a survey of the tissues of the adult human body, one to muscular tissue, one to glandular tissue, and the remainder to the nervous system.

The discussion of the cell and tissues is in general correctly stated, but is rather schematic and lacking in functional coloring. The critical student will note a number of minor errors, not all of which can be explained as due to the condensed form necessary in a work of this sort. A few examples are given.

On page 11 we read, "Every plant and every animal commences its individual life as a single cell." Exception should, of course, be made of the very large numbers of species which may be propagated by fission and budding. On page 26: "Vascular tissue; This includes the blood and lymph, the lymph glands and the red marrow of the bones, and develops from the endoderm." The endodermal origin of the blood cells is controverted, but there is no controversy regarding the mesodermal origin of some of the other tissues here mentioned. On page 29 the nuclei of pale striated muscle fibers are said to be marginal, while those of dark striated muscle fibers are located more centrally, embedded among the fibrils. The converse is true, as illustrated by the figure of human muscle printed on the

[1] Knight Dunlap. An Outline of Psychobiology. Baltimore, The Johns Hopkins Press, 1914, 121 pages, price $1.25.

same page. On page 41 the cochlea and possibly the sensory surfaces of the organs of smell and taste are said to migrate outward from the anterior part of the medullary tube. On page 58, line 2 from the bottom, for "spinal" ganglion of the cochlea, read *spiral* ganglion.

The chapters on the nervous tissues comprise a total of 62 pages. There are numerous good figures illustrating the nervous system and its elements, accompanied by a running description and lists of names of the parts figured; but here again there is a dearth of functional interpretation, and the reader who attempts to assimilate this description with no previous preparation in biology may find it rather indigestible. The neurological chapters contain a few infelicitous expressions, such as the following: .

There are several places in the descriptions of the nerves where the terms afferent and efferent are confused, some of these apparently being misprints. On page 82 we read, "Only four of the cranial nerves are, like the spinal, 'mixed nerves.' Of the other eight, three are pure afferent, or 'sensory,' and five are efferent, or 'motor'." But in the enumeration which follows the I, II and VIII pairs are described as afferent and the III, IV, V. VI, VII, and IX pairs are correctly described as mixed. There is no mention here of afferent fibers in the vagus and the "afferent axons of the spinal accessory" are said to supply the sterno-mastoid and trapezius muscles. On page 90, however, the afferent fibers of the vagus are referred to. On the page last mentioned the account of visceral fibers of the VII and X nerves is incorrect. The recent studies of Molhant, Yagita, Kosaka and others have clarified the relations of these systems.

The final chapter on the Functional Interrelation of Receptors, Neurons and Effectors is a very successful application of the author's cardinal principle (as stated in the Preface), that the body must be considered as a functional unit, and that this is even more important for psychology than for physiology. It is to be regretted that this principle, which is so well stated in general terms in this chapter, was not applied more explicitly and concretely in the descriptive part of the work. This brief final chapter alone is worth the price of the book.

HACHET-SOUPLET'S "DE L'ANIMAL A L'ENFANT"[1]

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In the present volume the author attempts to set forth the main outlines of an embryo science, that of comparative education. This discipline is to be based upon an experimental study of animals and children as opposed to the hitherto current *a priori* ideas. The child presents only a difference in degree and not in nature with respect to the higher animals. Hence methods of training suitable to the latter are applicable to the former. And Hachet-Souplet has had long experience in the training of animals.

In the elaboration of this program, the author treats first, animals and then children. His standard, however, is the child and animal life is interpreted in terms of this. The chapter headings and some of the topics of the first part are as follows: (1). Experimental study of sensations in animals. In addition to comments of a general nature, tests on pitch and visual intensity discrimination are described. Pigeons tested on the last problem gave results verifying Fechner's law—"du moins grossièrment," writes Hachet-Souplet. And one may well accept the qualification, for the most elementary precautions are ignored in the work which is hardly so scientific as the tests Galton once made with his whistle. (2). Fundamental and derived instincts. Hunger and fear (primitively the rejection of food) are fundamental and unmodifiable. Derived instincts are habits. It is interesting to note that the author does not follow Bergson in relating instinct and intelligence as opposites. (3) and (4). The experimental study of derived instincts. (5). The principal laws of the association of sensations. The chief law here is that of recurrence. Stimuli *d c b a* precede the reaction *r*. The associations formed remount from *a* to *d*. This law makes anticipation possible in that *d* or *c* can lead to *r* before *b* or *a* appears. At the close of this chapter the author announces

[1] Hachet-Souplet, P. De l'Animal à l'Enfant. Pp. 176. Paris, Alcan. 1913.

that "des expériences, poursuivies pendant dix ans à *l'Institut de psychologie zoologique*, ont permis d'établir que les habitudes imposées aux animaux sont transmissibles par héredité." The following six chapters deal with intellectual activity, the notion of causality, the notion of the physical me, abstraction, aesthetic taste and persuasion as a method of education. The discussion of causality centers on the use of tools and the devising of novel methods of securing results. Hachet-Souplet claims to have established the existence of these types of activity in animals. The presence of an idea of the physical me in phyla below man is asserted on the basis of two tests: (I) A dog that responds readily to the command "come" when alone will refuse to do so if he sits in company with other dogs. He will respond, however, when his *name* is called. He *knows* that there are other dogs present. (2) Monkeys will amuse themselves and grimace before a mirror. Critical comment is unnecessary here.

The second part of the book dealing with children includes four chapters: animal traits in children, punishment and reward, moral training, and instruction properly speaking. A firm discipline, a sort of "dressage" should be applied in early infancy in the light of the "law of recurrence."

It is unfortunate that rigorous scientific methods could not be applied where the opportunities are so great as they seem to be at the *Institut de psychologie zoologique*. In the reviewer's opinion attempts to combine behavior work and education in any intimate manner are at present far-fetched and are likely to result in the deterioration of the scientific character of the work.

KAFKA'S "EINFUHRUNG IN DIE TIERPSYCHOLOGIE" [1]

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If not an encyclopedia, Kafka's work is at least a very extensive compendium of the literature on invertebrate behavior. His sources are almost entirely experimental. A second volume is promised which will consider the senses of vertebrates and the development of the higher psychic capacities in the animal kingdom (instinct, memory, intelligence, etc.). It is that volume to which students will turn for Kafka's theoretical discussions which are to be based upon a wide survey of experimental facts. It is to be hoped that the war in Europe will not cause undue delay in this scientific enterprise, for the spirit of the first volume leads one to expect a sane handling of the literature and problems of the higher functional activities in the second volume.

The present work emphasizes the sensory processes of invertebrates, and the material is organized upon this basis. Touch (117 pages), the static sense (41 pages), hearing (33 pages), the temperature sense (15 pages), the chemical sense (97 pages), vision (156 pages), the space sense (53 pages) and the time sense (20 pages) are the chapter headings and the amounts of space allotted to each topic. In each of the above divisions the data are grouped according to animal phyla and genera—protozoa, coelenterates, worms, mollusks and arthropodes. This method of presentation has its defects as well as its advantages. It offers readier reference advantages to the zoologist who is interested in phyla than it does to the behaviorist who is interested in activities. The scheme allows no place for a summary of data bearing, e. g., upon tropisms and of the various theories thereof. Nor does it open the way to a statement of the essential facts of nervous integration. Such facts as are just indicated are to be found scattered throughout a large volume, if they

[1] Kafka, Gustav. Einführung in die Tierpsychologie. Bd. 1, S. xii+593. Leipzig, Barth, 1914.

are found at all. In some cases they are not even brought to the reader's attention in the subject index. One such case is that of tactile and auditory hairs. A volume placing emphasis upon sensory discrimination should contain a discussion or a summary of methods with evaluating comments thereon. This would give the reader a guide to the reliability of the data presented. An actual examination reveals that the method of general response is very universally applied. This can be supplemented by extirpation studies with certain forms. The association method in any definite form has not been so extensively used with the invertebrates. Further criticism in this same vein may be directed against the author's bibliography. Although this does not aim at completeness, it does aim at the inclusion of the most important works and of the most representative general references. The list given covers 28 pages. In the general list one misses such titles as: Wheeler "Ants"; Holmes "Evolution of Animal Intelligence"; and Max Meyer's "Laws of Human Behavior,"—which last deserves a place equally with many that are included. Other sins of omission might be indicated here and in the bibliographies in special subjects. I will call attention only to the lack of reference to McIndoo's "Lyriform Organs and Tactile Hairs of Araneads" and to the articles on taste and smell mentioned below. American investigations are referred to with great frequency.

One of the very excellent features of Kafka's work is the large number of illustrations given,—a total of 362 figures. These present the gross bodily appearance, the detailed anatomy of the sense organs and certain types of reactions of the animals concerned. Comparative psychologists will welcome a convenient summary of invertebrate sense organs. The teaching of the subject will gain by this emphasis upon structure even if research work does not need correction and an added incentive. Pedagogically important also are the references to the tropic activities of bacteria and the sex cells.

The intimate relations between touch and hearing are pointed out. The existence of auditory hairs furnishes supporting evidence here. No claim is made that the phenomena treated under audition are to be interpreted as essentially different from those of touch. The differentiation must be in terms of stimuli and these are proverbially hard to control. The general

problem of the criteria for distinguishing sense fields is not taken up. A special case that is considered is the relation of taste and smell. The differentiation here is on the basis of the topographical relations of the sense organs which lead to functional differences. Taste functions in the immediate taking of food while smell leads to the search for food. [In other words, it is a difference of extero and intero-ceptors.] If the question of the relation of taste and smell was to be handled at all, the author should by no means have ignored the work on this topic by C. J. Herrick, Parker and Parker and Stabler. The antennae of insects are held to contain the olfactory organs. Miss Fielde's work on the detailed anatomy of the antennae of ants is quoted with approval (?). In his discussion of the study of smell by extirpation methods, Kafka makes the very valuable suggestion that the presence of inadequate but effective stimuli must be reckoned with both in so far as they may affect cutaneous nerves and in so far as they may arouse activities in taste. The presence of this source of error is very probable where intense stimuli are used [and really can only be thoroughly guarded against when data on threshold sensitivities are at hand.]

In discussing the factors that cause insects to seek flowers, the author opposes Plateau's odor theory and supports Forel and others who find vision and habit the main factors. The recent work of Lovell furnishes additional confirmation of the truth of this point of view.

The treatment of vision is well executed. Phototropisms are discussed in detail and are interpreted from the standpoint of "trial and error" rather than from Loeb's point of view. The author points out (page 321) "dass die 'Richtung der Lichtstrahlen' an sich ein ebenso 'metaphysisches' Erklärungsprincip darstellt wie etwa die ' Willenstätigkeit,' gegen deren Heranziehung gerade die Vertreter der Tropismenlehre so energischen Einspruch erheben. Denn wie die Einstellung eines Organismus durch die *Richtung* bestimmt werden soll, in *der die Lichtstrahlen seine Körpersubstance durchsetzen* (Sachs), bleibt rätselhaft * * *." This chapter contains a large number of diagrams illustrating the discussion of the evolution of the invertebrate eye. In the presentation of the much be-labored field of insect color-vision, the author leans toward the interpretation that the behavior in question is guided by brightness only. Kafka

rarely introduces theoretical psychological comments and discussions into the text. It is a pleasure, however, here in the account of color-vision, to meet the following statement: "Die Vergleichende Psychologie vermag daher auf objectiven Wege das Problem des Farbensinnes der Insekten nur bis zu der Feststellung zu fördern, dass jedenfalls verschiedene Strahlengattungen verschiedene objective Wirkungen hervorbringen, sie kann dagegen auf die subjektiven Phänomene im tierischen Bewusstsein wiederum nur aus der Analogie der objektiven Vorgänge im menschlichen und im tierischen Organismus schliessen." (S. 473). Such analogies, the author further points out, are hindered by our lack of information concerning retinal processes in man.

American readers will note with interest Kafka's Introduction dealing with the aims and principles of comparative psychology.[1] It was written prior to the publication in this country of the many recent "Behavior" papers. In the present book, the discussion covers 16 pages only out of a total of 549. The "speculative tendency" thus plays no overshadowing rôle here.

The fact that comparative psychology has manifested an anthropomorphic tendency cannot be used as a final argument against the possibility of its being thoroughly scientific. Biology, physics and chemistry have passed through similar stages. Yet reacting against anthropomorphism, natural science tends to seek all explanation in physical and chemical terms or at most in the teleological conditioning of reactions. Conscious processes, since they cannot be "observed" are ruled out of the subject matter. There is no doubt that the rapid progress made by comparative physiology and biology within recent years has been largely due to the insistence that objective processes be stated in terms of objective factors. Appeals to psychic processes have most often indicated only the faliure to analyze properly a causal nexus. Yet that this physico-chemical statement is not exhaustive is testified to by the consciousness that each one has of mental concomitants of bodily activity as well as by the appeal to introspection which physiology makes in its studies of brain functions. The inaccessibility to immediate

[1] This chapter appeared, prior to the publication of the book, under the title "Ueber Grundlagen und Ziele einer wissenschaftlichen Tierpsychologie," *Arch. f. d. ges. Psych.*, Bd. 29, 1913.

experience of the facts for which comparative psychology seeks is no more a criticism of the scientific character of the field than is the impossibility of an immediate experience of the center of the earth and of the back side of the moon an objection to the sciences there concerned.

There is as much justification for attributing consciousness to animals as to one's fellow men. In neither case can immediate experience be had. It is useless to seek for objective criteria of consciousness, although one feels impelled to do so. One of the most important criteria proposed is the "associative memory" of Loeb and Bethe. This, however, assumes that memory is the first thing in the way of consciousness,—a theory which can be traced as far back as Hobbes and Locke. [K. does not mention the fact, but this criticism has been urged by other writers, S. J. Holmes, *et. al.*] Other criteria based upon the analogies of human and animal sense organs and nervous systems ignore the possibility of the existence of consciousnesses different from the human. The legitimate use of analogy directs attention to the similarity throughout the animal kingdom with respect to biological adjustments: self-preservation, continuation of the species, avoidance of pain and the seeking of pleasure. The continuity of life on the physical side suggests a similar continuity on the mental side. The psychologist's task is to trace origins and growths within the subjective realm which it is necessary to posit beside the physical world. From the uncertainty which attaches to any subject matter not open to immediate experience, comparative psychology derives only the "Verpflichtung, sich streng an die Ergebnisse der objektiven Forschung als ihre einzige Grundlage zu halten, ohne sich dazu verleiten zu lassen, psychologische Interpretationen als kausale Erklärungen der physischen Phänomene auszugeben." (S. 13).

The reviewer can heartily commend Kafka's general point of view. A safe middle ground is held with respect to a question where extreme doctrines are only too frequently current.

CESARESCO'S PSYCHOLOGY AND TRAINING OF THE HORSE[1]

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This work represents the product of life-long study and practice of the art of horsemanship. The first volume deals with the mental and physical nature of the horse; the remaining three volumes are devoted to the methods of training.

We are told that "the horse's intelligence is limited, but the animal is intelligent enough to understand that it must have regard for what happens in its environment, and for its rider,—to feel the justice or injustice of the punishments inflicted,—to try to oppose, anticipate, and neutralize the efforts of its rider,—and to choose that moment for injuring its master when the latter is not looking." "The horse," furthermore, "has a highly developed imagination," and this combined with its great susceptibility to fear, makes the animal readily amenable to our attempts to train it, for the one "enables it to grasp readily the idea of our superiority" and the other "gives value to the slightest stimulus or chastisement."

In whatever way we may react to these psychological interpretations, the account of the methods of training will possess a positive value for the student of animal behavior, *viz.:* as a stimulus toward the formulation of specific problems in connection with the behavior of the horse. Such a student will miss with regret, at times, the minute analyses of stimulus and the significant classifications and tabulations of responses which, *e. g.*, make the work of Pfungst so valuable. Thus the changes in the voice of the rider are emphasized as one of the most effective helps, or means of control, and it would have been highly desirable to have had an analysis of the kinds of qualitative or other changes in the form of stimulation that constitute the really effective factor. At other points in the treatise

[1] Cesaresco, Count Eugenio Mantinengo: L'Arte Di Cavalcare, Con Aggiunto: Il Cavallo Attaccato Alla Carrozza. Devoti, Salò, 1914.

such a criticism will not, of course, hold: for instance in the description of gestures and caresses as inducing stimuli. In the main, however, the reader is left with a feeling that the description is couched too often in subjective terms such as: "approval," "disapproval," "menacing." . . . . But the student will find suggested, on the other hand, a wealth of problems peculiarly significant. And their significance lies in this: that the horse presents, probably more favorably than any other form, opportunities for studying a mechanism of stimulus and response approximating very closely the typical social situation.

If Pfungst's work establishes the fact of a fine perception of minimal movements of all kinds, as involved in the functionally effective stimulus for responses in the horse, the treatise of Cesaresco indicates what appears to be the salient characteristic of the responsive phase, *viz.*: a finely balanced inhibition-mechanism. It is this fact, plus the sensitiveness of the horse to minimal changes in stimulation while the response is in progress, that makes its behavior so closely analogous to the reaction of the human individual in the social situation.

S. J.